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PINTSCH GAS PLANT, MANHATTAN ELEVATED RAILROAD, NEW YORK.

During the fifteen years of its use in the United States, the Pintsch system of car lighting has met with remarkable success. This is due to the combination of efficiency in lighting and the employment of a gas which may be compressed and stored for transportation without material loss of illuminating power.

There are now about 85,000 railroad cars and over 4,000 locomotives using the system, and it is also applied with equal success in the lighting of buoys for marking channels in harbors and rivers. The buoy lights burn continuously from six to eight months, according to their size, without attention.

Pintsch gas is made from a high grade petroleum distillate, and is a fixed gas, which when compressed has an illuminating power six times as high as that of coal gas, known as "city gas," in the same condition. While city gas loses nearly all of its illuminating power by compression, Pintsch gas loses only about 10 per cent., and its candle power is about 65 when compressed to 14 atmospheres.

The process of manufacture liberates the gas from the oil, and it removes the tar and impurities by condensation and purification, after which the gas is compressed into storage tanks, and from them it is admitted to the distributing mains for charging the car reservoirs. In passing from the car reservoirs at a pressure of 12 atmospheres or less the gas goes through a regulator, which reduces the pressure to about one-third of an ounce per square inch at the burners, maintaining a steady, even flame, regardless of the varying pressure of the reservoir. It is a very ingenious device, and is one of the important parts of the system.

Forty Pintsch gas plants are now operated at the important railroad centers in the United States by the Pintsch Compressing Company. One of the largest of these has 30 miles of distributing mains, supplying 28 different railroads, and altogether these plants supply 1,200 Pullman, 500 Wagner and 10,800 passenger coaches on 110 different railroads. The plants are exceedingly compact and well arranged, the latest and most interesting being that installed 18 months ago at 159th St., New York City, for supplying daily 1,100 cars of the Manhattan Elevated Railroad.

The gas is made in a two-story, 50 by 65 feet, brick building, and the whole plant, aside from the distributing system, occupies a ground space of about 60 by 136 feet. Besides being the newest plant, this one is interesting because of improvements in the retorts, which give a greater capacity with two fires than was formerly had with thirty. It also permits of better control of the quality of the gas. In general, the plant consists of the oil storage tanks, holding the raw material, a 50-gallon supply tank elevated inside the retort house, the retorts, condenser, exhauster, washer, purifiers, meter, gas holder, compressors, store holders for the compressed gas, and, finally, the distribution system. Fig. 1 is an exterior view of the plant; Fig. 2 is a diagram showing the process from the beginning up to the compression; Fig. 3 is a plan of the first floor of the building; Fig. 4 is the oil ends, and Fig. 5 the gas ends of the retorts; Fig. 6 shows the condenser and purifiers in a room over the compressors; Fig. 7 is the exhauster; Fig. 8 the compressors, and Fig. 9 a view of the valve gear of one of the compressors.

The oil supply tanks are underground outside of the building, and have a capacity for 25,000 gallons. A small pump in the retort house raises the oil to the supply tank as it is required, and from there it is sent by gravity to the retorts through graduated valves. The small tank is used to keep down the amount of oil in the retort house to the lowest terms as a measure of safety.

Formerly the retorts for Pintsch gas were of iron, and the improvement is in the substitution of clay. Clay retorts have been used for the manufacture of coal gas, and also to some extent for oil gas, but never before in this manner for making the gas used for car lighting. Clay withstands heat better than iron, and it lasts longer, but it requires continuous service, and is adapted only to plants of large capacity. These retorts may be made three times as large as iron for the same expense, and are economical because of the possibility of using fewer fires for the same work. Their use was to a certain extent experimental in this case, and it is now an assured success.

The retorts are of D section, 3 inches thick and 20 feet long, with a mouthpiece and self-sealing lid on each end. They are laid horizontally in two benches of six retorts each, and are heated by two coke fires in regenerative furnaces 30 inches wide by 6 feet deep, so designed as to heat the retorts evenly from end to end. The stoking door is at the floor level and in the center of the brick work, the ash pits being below the floor.

The hot gases from the fire reach the central portions of the retorts first, where they are mixed with a supply of fresh, heated air, inducing further combustion, which is completed by further additions of air at the top of the combustion chamber. The products of total combustion are led through flues to the chimney, their heat being utilized to heat the secondary air supply already referred to.

The oil is conducted from the supply tank to each retort by a separate pipe, with special devices for controlling its flow. Two of these connections are shown in Fig. 2, the others being omitted for the sake of clearness. After entering the retort the oil passes to the front through a 2½-inch pipe laid along the bottom of the retort. At the end farthest from the entrance this pipe has a return bend connection to a 4-inch pipe leading along beside the 2½-inch pipe to a point near the entering end, from which the gas is sent to the front again through the open retort. These pipes in the retort are turned up into a vertical plane in Fig. 2 in order to show them in the engraving. In reality, they lie along the bottom of the retort. These vaporizing pipes cause the oil to heat gradually, and they are necessary in order to vaporize the oil before it comes into contact with the clay. The adjustment of the flow of oil to the temperature of the retorts is important and requires careful attention in order to give a uniform product.

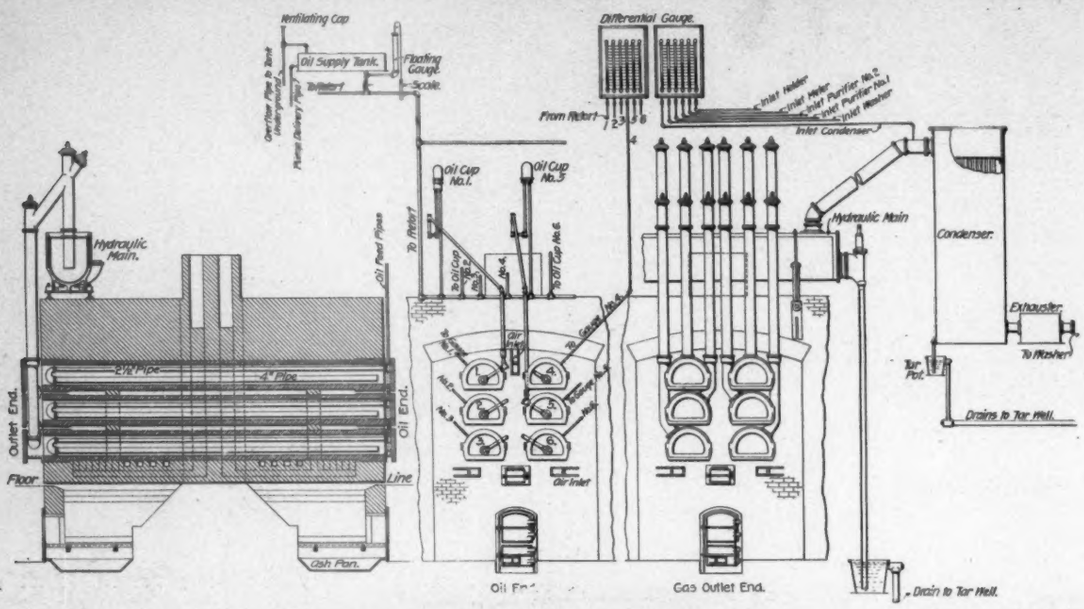


Fig. 2.—Showing Complete Gas Making Process.

(This Engraving Shows Process as far as the Washer. See opposite page.)

Fig. 1.—Exterior View of Plant.

Fig. 4.—Oil End of Retorts.

Fig. 5.—Gas End of Retorts.

Fig. 6.—Condenser, Washer and Purifiers.

PINTSCH GAS PLANT—MANHATTAN ELEVATED RAILWAY, NEW YORK.

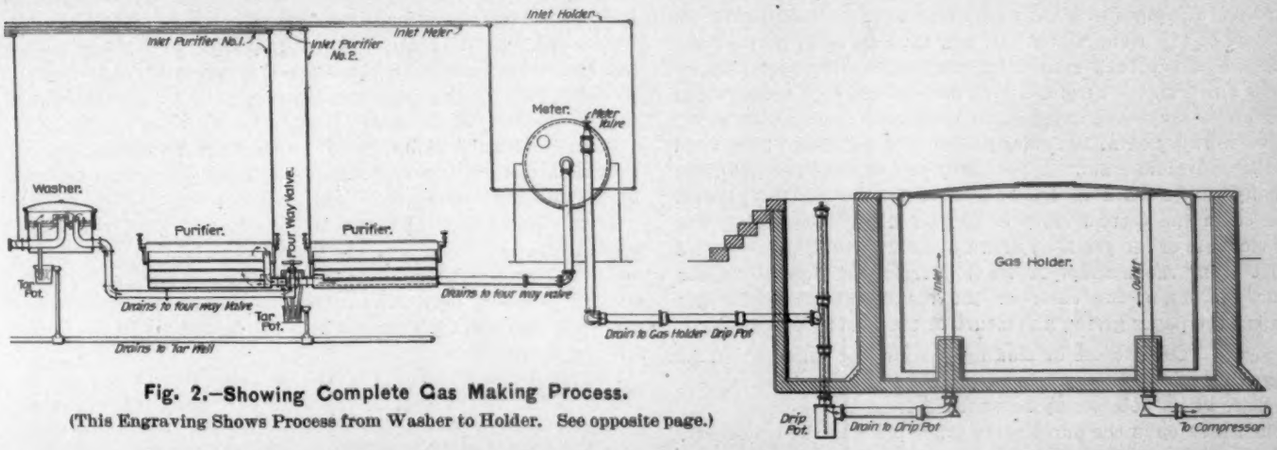


Fig. 2.—Showing Complete Gas Making Process.
(This Engraving Shows Process from Washer to Holder. See opposite page.)

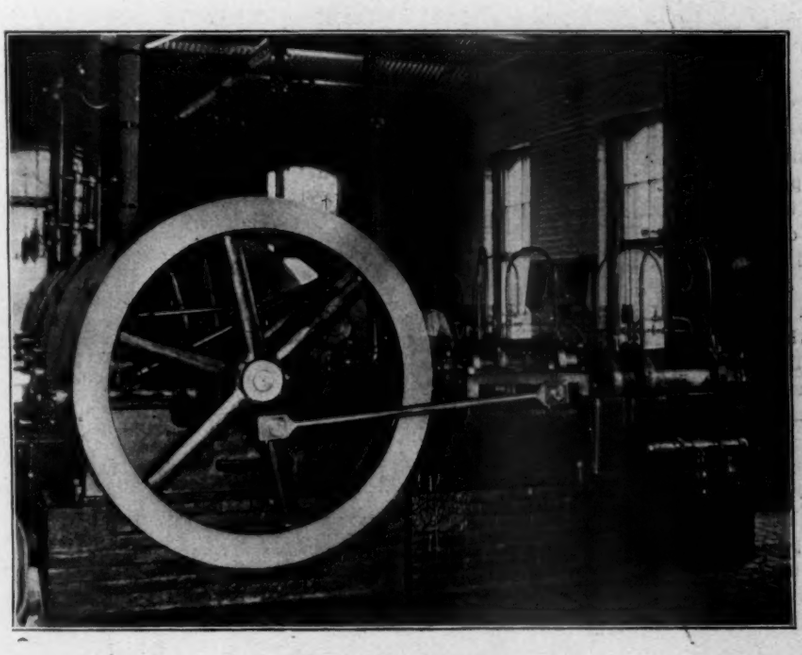


Fig. 8.—Compressors.

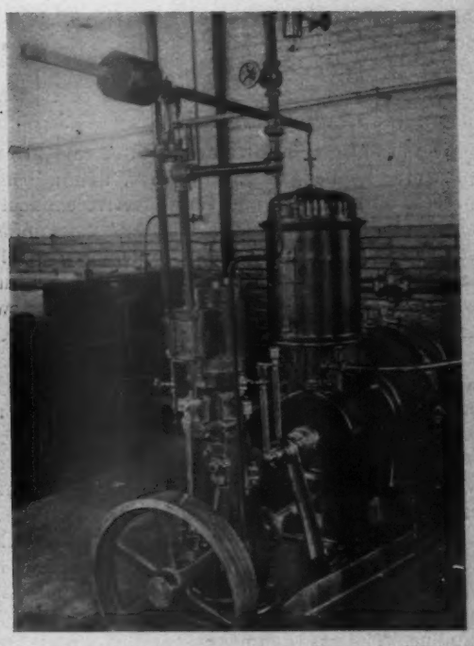


Fig. 7.—Exhauster.

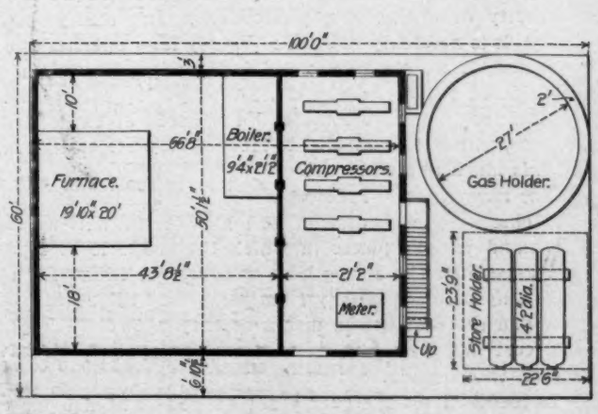


Fig. 3.—Plan of Ground Floor of Plant.

Fig. 9.—Simple Valve Gear of Compressors.

PINTSCH GAS PLANT—MANHATTAN ELEVATED RAILWAY, NEW YORK.

The gas leaves the front ends of the retort through 6-inch vertical cast-iron pipes, connecting each retort to the hydraulic main overhead. The gas passes into the hydraulic main through dip pipes, the ends of which are one inch below the surface of the accumulated tar, and thus serve to prevent any passage of gas back into an unused retort. The level of the tar is uniform, the surplus above that needed for the sealing of the pipes are being drained to a tank for storage. A safety valve, blowing off at 12 inches pressure, is connected to the end of the hydraulic main. A 10-inch pipe conducts the gas from the hydraulic main to the condenser in the purifying room located in the second story of the building. A running test for richness of the gas is applied by holding white paper before a jet from the standpipes leading from the retorts to the hydraulic main, the color of the stains made by the gas against the paper giving a measure of the quality of the gas.

In Fig. 2 the process of making gas may be followed. This engraving shows the system of pressure gauges, whereby the pressure at all points may be watched from the retorts.

The first step in the purification takes place in the condenser, which resembles a vertical tubular boiler, the gas passing inside and cold water outside of the tubes. It is seen at the left in Fig. 6. This removes all of the moisture and tar, and, in fact, everything that may be taken out of the gas by cooling. The tar and condensation drain off to the tar well. Fig. 6 shows the room in the second story of the building.

The use of clay retorts necessitates careful regulation of the pressure of the gas within them, and at this point in the process an ingenious and very effective exhauster is employed, shown in Fig. 7. This is a rotary wing pump driven by a steam engine, the throttle of which is controlled by a regulator so sensitive that it will maintain a pressure of 1 inch of water at all times in the retorts. The clay will not permit more than this amount of pressure, which makes this machine one of the essentials of the clay retort system. The machine works admirably, being entirely automatic. The exhauster passes the gas to the washer or scrubber, for removal of the products requiring mechanical operation. Here the gas is washed with water under a plate with ribs projecting downward, which cause the gas to bubble along in the water, finally passing through an outlet pipe to the purifiers. The washer is seen in front of the condenser in Fig. 6, and the purifiers are at the right, with the large covers, which may be lifted off by the chain hoists. In the purifiers the gas passes through large trays covered with lime or iron oxide for the removal of the sulphur. The gas then passes through a meter having a capacity of 8,000 cubic feet per hour, and goes to the gas holder outside of the building. It is then ready for compression, and at this stage tests of its quality are made by Hemple's method of absorption and by the photometer. The photometer room is well fitted up for testing the lighting power, a gas flame with a slit screen being used instead of standard candles.

The compressors, of which there are four, shown in Fig. 8, are excellent machines, worthy of a more extended description than the scope of this article permits. They were built by the Pintsch Compressing Company and are the outcome of long experience. The great care in the design and construction is manifested in their operation. A unique feature in the method of compressing at this plant is that it is done in two stages, with separate engines for each operation. This is done for the sake of economy in the number of machines and in the floor space required, as well as economy in operation. All of the compressors are compound, the steam cylinders being all alike, with 6 and 12 by 18-inch cylinders. The gas cylinders are 7 by 18 and 14 by 18 inches. The steam is distributed by D valves working on cylindrical surfaces and actuated by a single eccentric, an extremely simple valve motion (Fig. 9). The gas cylinders are water-cooled and have steel bushings. The inlet and outlet valves are in bonnets on the cylinder heads, and are accessible for inspection and renewal. The theoretical limit of the first compression is the square root of the total pressure, and the first stage in this case is about 3½ atmospheres, the pressure of the second stage being between 13 and 14 atmospheres.

The compression and cooling from the second stage deposits hydro-carbons, which are collected in pots outside of the building and under ground, from which they are sent to the small elevated tank in the right-hand corner of the purifying room by the pressure of the gas.

Steam is furnished by an 80 horse-power horizontal return tubular boiler, with a 75 horse-power submerged tube vertical boiler as a reserve.

After compression the gas is stored in five of the large welded steel store-holders shown at the right of the retort house in Fig. 1. The sixth of these holders is used as a reservoir or receiver between the low and high pressure compressors. Each of the store-holders has a capacity of 265 cubic feet per atmosphere.

The plant has a capacity of 150,000 cubic feet of gas per 24 hours, and is the largest of the kind ever installed. It is so arranged so as to provide for a reserve capacity of 100 per cent. for future extensions.

The piping system includes about 11 miles of extra strong 2-inch mains, all under a pressure of about 14 atmospheres. The mains have expansion bends, about a half mile apart, and are conducted along the elevated structure. In spite of the pressure and the extent of the line, there is a loss of less than 10 per cent.

The charging of the cars is done in five yards, and is performed with great rapidity by means of special hose fittings arranged for quick attachment and release. The chief charging stations are near the gas plant at 155th St., and at Second Ave. and 129th St. A pipe leads to the yard at 145th St. on Eighth and Sixth Aves., crossing over to Third Ave., where it returns to the 129th St. station for the Third and Second Ave. lines.

The car lamps with clusters of ¾-foot burners give about 40 candle power each.

CAST IRON IN RAILWAY PRACTICE.

By G. R. Henderson, Mechanical Engineer, and W. Walley Davis, Chemist, Norfolk & Western Railway.

Cast iron is a much maligned metal, as far as engineering structures are concerned, but it is withal a very important one. Being one of the earliest forms in which iron was produced, it was used in places where to-day no one would think of suggesting it, until fatal accidents proclaimed it unsuitable for certain parts of important works, but, nevertheless, it is still an almost indispensable material in the great majority of engineering productions. Its utility being so great, it is necessary to carefully study its properties and composition, if we are to use it intelligently and without being considered reckless designers. A proper appreciation of the difficulties to be overcome and the needs of each particular casting will often enable us to make a very useful material out of this much abused metal.

For many uses in railroad work, such as most car castings, the cheaper grades of iron will answer, as well as for the thousand various pieces in which the shape is of more importance than the strength or wearing qualities. Such castings may be made largely from scrap, and the silicon will be low and the castings hard, but as they answer their purpose and cost but three-fourths of a cent per pound, we have no reason to complain.

In locomotives, a higher grade of iron is needed for cylinders, valves, driving wheel centres, driving boxes, etc. At the same time the metal must be such that it can be readily worked in the machine shop. Several years ago the writer, in endeavoring to provide a stronger metal than the ordinary run of cast iron for the purposes just enumerated, after some experimenting concluded that a metal produced by charging 20 per cent. No. 2 coke pig, 20 per cent. steel scrap (old

springs, sheet clippings, punchings, etc.) and 60 per cent. of cast iron scrap was suitable and available. Test bars demonstrated that this metal was about 20 per cent. stronger and 10 per cent. more flexible than the ordinary mixtures in use, and at the same time presented a good wearing surface—smooth and hard—without an undue amount of time spent in machining.

About the same time Mr. S. M. Vauclain, Superintendent of the Baldwin Locomotive Works, attacking the subject in a different way, produced a metal with similar characteristics and an almost identical analysis, as the following comparison will show:

Elements.	Our metal.	Vauclain's metal.
Graphitic carbon	2.45 per cent.	....
Combined carbon	0.62 "	0.55
Silicon	1.51 "	1.47
Manganese	0.33 "	0.34
Phosphorus	0.65 "	0.65
Sulphur	0.068 "	0.10

(For details of these mixtures, etc., see page 208, Proceedings of Master Mechanics' Association for 1897.)

Perhaps the greatest care in selecting and grading the mixtures is required in the manufacture of car-wheels. For many years a guarantee of service was the only condition imposed upon the wheel-makers, but later the drop test was substituted by some companies for the guarantee. More recently the thermal test was introduced, thereby increasing the difficulties of the wheel-founder. While this test is considered by some as exceedingly severe, yet it is probably the nearest approach to service conditions that can be readily produced. It will be seen from the above that there are three principal features required of the wheels, namely—immunity from rapid wear, strength to resist shocks, and ability to withstand expansive strains due to abnormal heating of the rim. It has been considered by many that those elements in a chilling iron which tend to enhance the wearing qualities of a wheel are antagonistic to those required in order to successfully pass the drop and thermal tests. For example, it has been found from a series of carefully conducted experiments that manganese can be largely depended upon to give the wheel the requisite qualities to pass the thermal and drop tests, but this at the same time causes a reduction in the depth of the chill, consequently reducing the wearing qualities of the wheel. This will be explained more fully later on, being touched upon here as an illustration of the foregoing statement.

Mr. S. P. Bush, before the M. C. B. Association, last summer, in discussing the thermal tests for car wheels, gave a series of analyses to demonstrate the fact that the material in the plates or gray iron might vary considerably, yet it was possible to produce an almost identical carbon structure in the chilled portion.

This would tend to indicate that the form and not the amount of carbon determines the hardness of a chilled metal. What applies to the chill applies equally to the unchilled portion, the form of the combined carbon undoubtedly having a great bearing upon the character of the material.

In our examination of the subject there were upward of seventy car-wheels tested and analyzed. These were selected on account of failure to stand thermal or drop tests, or to give a respectable service under cars, or by reason of the fact that they had stood satisfactorily severe drop or thermal tests or had given an extended road service. In each case the chill was determined and a full analysis made of the metal in the plate.

Table No. 1 gives the information derived from these examinations.

In order to better study the problem, this information was reduced to a graphical representation illustrated by the diagrams, Figs. 1, 2 and 3.

The ordinates show the chemical composition of the different wheels, grouped according to their ability to stand test of service. In each diagram the poor wheels are grouped in the left hand column and the best wheels in right hand column. The variations in chemical composition are significant. These diagrams are shown in the form of zones, the lines for individual wheels being too fine to reproduce.

Examining first the graphitic carbon, in all the diagrams, the poor wheels are those low in this element, while the good wheels contain a large proportion of it. The combined carbon, as a rule, follows an inverse ratio. Silicon does not seem to take a very prominent part in affecting the physical properties of the wheels examined. As far as the thermal and drop tests are concerned, the amount of manganese is important; the greater the quantity the better the wheel stands the test. Large quantities of sulphur and phosphorus are, of course, objectionable, but within the limits in which they occur do not seem to affect the wheels particularly.

We give below a tabulated statement of the limits of different elements represented by the best wheels in each set of tests:

TABLE No. 1.

Throat chill.	Tread chill.	Drop blows.	Thermal test.	Service.	C.C.	G. C.	Si.	Mn.	S.	P.
..	..	..	0	....	.79	2.65	.72	.41	.06	.45
1/4	5/8	24	....	....	.63	2.87	.57	.33	.07	.41
7/32	9/16	9	..	8½ yrs.	.66	2.75	.67	.31	.05	.35
9/32	5/8	..	60 min.	8½ "	.61	3.19	.57	.34	.06	.31
5/16	11/16	..	0	7½ "	.56	3.14	.72	.26	.07	.35
11/32	3/4	..	38 sec.	....	1.09	2.34	.71	.03	.08	.40
3/8	7/8	..	0	....	.50	3.21	.71	.40	.06	.37
13/32	15/16	..	0	....	.71	2.82	.74	.42	.06	.36
7/16	1	..	....	1 mo.	.99	2.66	.81	.29	.05	.44
15/32	1 1/16	53	10 min.	....	.55	3.31	.61	.43	.06	.36
17/32	1 1/8	..	0	....	.70	3.09	.52	.40	.06	.39
9/16	1 3/16	..	0	....	.60	3 28	.58	.30	06	.37
..	1 1/4	..	....	....	.76	2.97	.69	.23	.07	.41
..	1 5/16	28	....	....	.81	2.80	.55	.27	.07	.49
..	1 3/8	..	90 min.	5 yrs.	.80	2 55	.84	.20	.07	.42
19/32	1 7/16	..	....	2 mos.	.73	2.75	.56	.32	.08	.48
5/8	1 1/2	..	....	4½ yrs.	.88	2 65	.59	.29	.06	.45
21/32	1 9/16	..	0	4½ yrs.	.79	2.48	.49	.51	.06	.44
11/16	1 5/8	..	....	....	.32	3.51	.62	.32	.06	.31
23/32	1 11/16	..	....	....	1.14	1.90	.74	.22	.12	.43
3/4	1	..	....	1½ yr.	.73	2.46	.68	.22	.09	.43
25/32	1 1/16	..	1 m. 20 sec.	...	.68	2 75	.56	.53	.05	.46
13/16	1 1/8	34	....	....	.99	2.45	.65	.15	.05	.40
27/32	1 3/16	..	....	1 mo.	1.05	2.35	.33	.16	.05	.39
7/8	1 1/4	..	....	1 mo.	.77	2.72	.54	.37	.07	.44
29/32	1 5/16	..	0	....	.76	2 65	.58	.44	.09	.44
15/16	1 3/8	45	....	....	.95	2.70	.67	.53	.09	.41
31/32	1 7/16	..	0	....	.65	2.74	.64	.46	.08	.43
1	1 1/2	46	....	....	1.12	2 29	.87	.22	.10	.39
1 1/32	1 9/16	..	....	5 mos.	1.42	1.96	.80	.29	.10	.41
1 1/16	1	..	....	....	.66	2.32	.62	.32	.10	.41
1 3/32	1 11/16	..	....	5 mos.	.63	2.72	.75	.45	.07	.45
1 1/8	1 3/4	..	0	....	.72	2.73	.51	.37	.07	.48
1 5/32	1 13/16	51	0	....	73	2.83	.56	.39	.06	.44
1 3/16	1 7/8	55	....	....	.85	2.73	.71	.35	.07	.39
1 7/32	1 15/16	48	....	....	.73	2.87	.66	.39	.06	.42
1 1/4	2	..	6 min.	....	.66	2.83	.59	.43	.07	.52
1 9/32	2 1/16	41	....	....	.78	2.77	.61	.47	.07	.43
1 5/16	2 1/8	40	....	....	.90	2.74	.49	.47	.08	.43
1 11/32	2 3/16	..	2 m. 5 s.	....	1.40	2.12	.80	.15	07	.44
1 3/8	2 1/4	..	....	8 mos.	1.40	2.21	.81	.12	.07	.37
1 13/32	2 5/16	..	....	4 mos.	1.40	2.07	.69	.16	.07	.44
..	..	..	....	5 mos.	.47	2.94	.63	.39	.07	.44
..	..	..	Burst in mounting.		.91	2.85	.58	.41	.04	.43
1 7/16	2 3/8	49	....	....	.81	2.62	.61	.28	.06	.40
1 15/32	2 7/16	..	3 m. 5 s.	..	.74	2.73	.67	.24	.05	.45
..	..	47	..	...	.79	2.85	.55	.25	.07	.45
..	..	..	....	....	1.09	2.47	.55	.24	.06	.39
1 1/2	2 1/2	..	Burst in mounting.		1.19	2.23	.55	.11	.08	.42
1 17/32	2 9/16	28	....	....	1.25	2.33	.94	.13	.09	.32
1 9/16	2 5/8	..	....	13 yrs.	.93	2.46	.56	.15	.06	.42
1 19/32	2 11/16	..	....	1 yr.	.65	2.82	.58	.25	.07	.43
1 5/8	2 3/4	34	....	....	.55	3.14	.55	.36	.07	.43
1 21/32	2 13/16	..	Burst in mounting.		.53	2.99	.69	.29	.07	.48
1 11/16	2 7/8	..	90 min.	....	.46	3.07	.59	.31	.07	.49
1 23/32	2 15/16	..	90 min.	....	.86	2.57	.62	.18	.06	.50
1 3/4	3	..	....	6 mos.	1.22	2.28	.68	.12	.06	.54
1 25/32	3 1/16	..	....	4 mos.	.65	2.86	.71	.26	.07	.44
1 13/16	3 1/8	..	45 min.	....	.58	2.94	.55	.22	.07	.39
..	..	..	0	....	.73	2.90	.72	.28	.08	.44
1 27/32	3 3/16	..	50 min.	....	.70	2.80	.50	.21	.06	.30
1 7/8	3 1/4	..	60 min.	....	1.06	2.72	.73	.19	.07	.43
1 29/32	3 5/16	..	....	10 mos.	1 18	2.31	.58	.13	.06	.41
1 15/16	3 3/8	..	....	1 mo.	.65	2.90	.60	.16	.05	.30
1 31/32	3 7/16	..	....	4½ yrs.	.70	2.85	.68	.30	.07	.41
2	3 1/2	58	...	....	.96	2 48	.87	.20	.07	.49
2 1/32	3 9/16	..	....	10 mos.	.65	3.05	.60	.27	.07	.44
2 1/16	3 5/8	..	....	4½ yrs.	.84	2.48	.49	.24	.08	.44
2 3/32	3 11/16	32	...	....	.88	3.10	.58	.22	.06	.30
2 1/8	3 3/4	..	....	9 yrs.	.78	2.89	.60	.24	.06	.34
2 5/32	3 13/16	..	....	9 yrs.	.71	2.86	.68	.22	.08	.25
2 3/16	3 7/8	..	....	9 yrs.	.63	2.89	.66	.26	.07	.34
2 7/32	3 15/16	..	....	11 yrs.	1.01	2.56	.64	.18	.07	.30
2 1/4	4	..	....	9 yrs.	.77	2.91	.68	.27	.06	.45
2 9/32	4 1/16	..	....	10 yrs.	.66	2.84	.62	.15	.05	.43
2 5/16	4 1/8	..	....	8 yrs.						

"O" under "Thermal Test" means "did not crack." Samples taken from inner surface of rim towards the chill.

TABLE NO. 2.

(In per cent.)

Good Wheel Analysis.

	Thermal.		Drop.		Service.	
	Max.	Min.	Max.	Min.	Max.	Min.
G. C	3.28	2.65	3.31	2.65	3.18	2.23
C. C	.95	.32	.90	.55	1.24	.56
Si	.75	.50	.70	.50	.94	.58
Mn	.53	.20	.46	.24	.34	.13
S	.088	.055	.086	.040	.085	.047
P	.48	.35	.52	.36	.49	.25

These limits are naturally rather wide, but we give below what we consider the desirable limits for the chemical constituents in wheels.

TABLE NO. 3.

Desirable Wheel Analysis.

	Per cent.
Graphitic carbon	2 75 to 3.00
Combined carbon	.50 to .75
Manganese	.30 to .50
Silicon	.50 to .70
Sulphur	.05 to .07
Phosphorus	.35 to .45

The total carbon should run about 3.50 per cent., and the silicon and manganese together should make about .90 to 1.00 per cent.

In order to demonstrate that these limits apply to wheels which have given good service, we tabulate below in similar form the maximum and minimum limits of the last seven wheels in table No. 1, which gave from eight to eleven years' service:

TABLE NO. 4.

Limits of Good Wheels.

	Per cent.
Graphitic carbon	2.56 to 3.10
Combined carbon	0.66 to 1.01
Silicon	0.58 to 0.68
Manganese	0.15 to 0.27
Sulphur	0.05 to 0.08
Phosphorus	0.25 to 0.45

Out of twenty-two wheels in table No. 1 which cracked under thermal test in ten minutes or less, or did not give over two years' service, we find that all but one failed to come within the limits given in table No. 3. This would seem to indicate that this table would exclude wheels which did not have desirable proportions, and yet is well within the limits of wheels which will give good service and pass the thermal and drop tests.

The analyses given below, taken from the report of Mr. S. P. Bush to the Master Car Builders' Association last Summer, rather confirm table No. 3:

ANALYSIS OF THE GREY IRON.

Stood Thermal Test.

(In per cent.)

Total carbon.	Graphitic carbon.	Combined carbon.	Manganese.	Phosphorus.	Silicon.	Sulphur.
3.68	3.00	0.68	0.64	0.30	0.56	0.11
3 54	2.74	0.80	0.28	0.47	0.65	0.10
3.50	3.48	0.02	0.35	0.40	0.45	0.13
3.65	2.41	1.24	0.31	0.53	0.57	0.16
3 73	2.89	0,84	0.83	0.38	0.50	0.11
3.63	3.03	0.60	0.44	0.13	0.56	0.12
3.67	2.70	0.97	0.24	0.38	0.53	0 10
3.67	3.03	0.64	0.32	0.42	0.47	0.16
3.64	2.53	1.11	0.33	0.50	0.62	0.12
3.86	3.31	0.55	0.30	0.36	0.63	0.11

Did Not Stand Thermal Test.

Total carbon.	Graphitic carbon.	Combined carbon.	Manganese.	Phosphorus.	Silicon.	Sulphur.
3.64	2.41	1.23	0.30	0.35	0.71	0.14
3.22	1.98	1.24	0.34	0.51	0.77	0.16
3.51	2.56	0.95	0.31	0.44	0.75	0.12
3.64	2.30	1.34	0.21	0.39	0.65	0.13
3.61	2.52	1.09	0.17	0.35	0.60	0.11
3 61	2.94	0.67	0.33	0.42	0.79	0.12
3.73	2.60	1.13	0.23	0.35	0.66	0.11
3.68	2.54	1.14	0.19	0.39	0.88	0.12
3.74	2.57	1.17	0.30	0.41	0.60	0.13
3.45	2.39	1.06	0.40	0.36	0.68	0.19

Having developed what we consider the proper limits of the chemical constituents of wheels, it is necessary to determine which irons most readily fulfill these requirements. Twenty-seven samples of charcoal irons were examined chemically and physically, and table No. 5 gives the results of analysis and transverse test. The analyses were taken from the pig, and the physical test made upon bars two inches square resting on supports 21 1-3 inches apart, the transverse load being applied at the center of the bar. The figures in the last two columns give the center breaking load, and the deflection just before breaking:

TABLE NO. 5.

Analyses of Charcoal Irons.

Ref. No.	Grade No.	C. C.	G. C.	Si.	Mn	S.	P.	Centre Load.	Deflection.
		%	%	%	%	%	%	Lbs.	Inches.
1	4	1.70	2.23	0.42	0.37	Trace.	.20	8,000	.110
2	2	1.01	3.16	1.27	0.85	.005	.22	8,000	.170
3	4	0.66	3.01	0 51	0.55	.030	.37	8,500	.110
4	2	0.50	3.59	0.71	0.70	.011	.43	9,500	.170
5	2	0.70	3.12	0.76	0.33	Trace.	.22	8,500	.155
6	3	0.64	2.49	1.20	0.30	.003	.23	12,500	.205
7	4	0.73	2.29	1.50	1.17	.030	.41	14,000	.220
8	4½	0.67	2.21	0.89	0.86	.031	.38	16,000	.240
9	4	0.92	2.46	0.83	0.84	.015	.36	14,000	.220
10	2	0 65	2 96	1.62	1.92	.004	.41	9,500	.200
11	4	0.91	2.87	0.70	0 24	.005	.19	8,000	.130
12	4	0.59	2.88	0.39	0.15	.005	.23	7,500	.070
13	2	0.21	3.39	1.27	0.33	.004	.27	8,500	.210
14	3	0.48	3.56	0.46	0.31	.008	.44	8,700	.130
15	2	0.73	3.13	0.79	0.44	.031	.41	11,000	.140
16	3	1.32	2.41	0.93	0.50	.012	.33	10,500	.205
17	2	0.47	2.95	1.41	0.62	.016	.33	9,000	.200
18	3	0.32	2.24	2.30	(.45	.025	.27	14,000	.200
19	4	0.75	2.11	1.73	0.87	.037	.33	13,500	.190
20	2	0.49	2.31	1.75	0.61	.032	.31	15,000	.240
21	4	0.82	2.57	0.37	0.27	.011	.43	9,000	.100
22	5	1.00	1.93	0.39	0.32	.006	.36	6,000	.070
23	3	0.48	3.01	1.06	1.10	.008	.33	9,500	.190
24	2	0.91	3 15	1.32	1 25	.005	.37	9,500	.210
25	4	0.84	2.77	0.76	0.60	.011	.66	13,500	.220
26	4	1.56	1.81	0.90	0.10	.013	.35	7,800	.090
27	3	1.10	2.50	1.01	0 19	.024	.46	12,000	.205

For obvious reasons the names of the furnaces have been omitted, but examination of the last two columns indicates that Nos. 6, 7, 8, 9, 18, 19, 20 and 25 are particularly suitable, whereas Nos. 1, 2, 3, 4, 5, 11, 12, 13, 14, 21 and 26 are noticeably weak and unsuitable.

Fig. 4 is a photographic representation of the depth of chill and appearance of fracture of the chilled test bars. These bars were 2 inches square, and the scale at the top affords a means of measuring the amount of chill. It is considered better for the white iron to blend gradually with the gray, and the photograph shows plainly which irons are most perfect in this respect. This engraving may be used to select irons by their chill, and as the results are from bars made by remelting from the pig, nearly the same amount of chill may be expected in the wheel.

There should be at all times a sufficient variety of irons in stock to enable the founder to quickly and easily adjust his charges to rectify any local disturbance in the cupola or blast, or variations in the shipments of iron. This can only be done intelligently by having a complete knowledge of the properties of the various irons in stock, and to this end all shipments should be carefully analyzed. New or doubtful irons should also have physical tests made and recorded. As certain elements change their form in the cupola, it is necessary to charge the furnace so as to allow for this. Thus, if we desire wheel metal in accordance with our suggested proportions, we should proceed as indicated below:

Analysis.	Metal desired.	Metal charged.
Graphitic carbon	2.80 per cent.	3.00 per cent.
Combined carbon	.70 "	.50 "
Silicon	.60 "	.65 "
Manganese	.40 "	.50 "

The proportions to be used can only be determined by experience, and by constantly watching and testing the output.

The use of scrap always causes an amount of uncertainty. If the scrap wheels are entirely our own make, some dependence can be placed upon their composition, but this is seldom possible. The only practicable way to grade old wheels seems to be by the fracture, when breaking them under the drop. If a chemical analysis could be had, there would be little doubt about them, but this is not feasible. For this

TESTS AND SERVICE RECORDS.

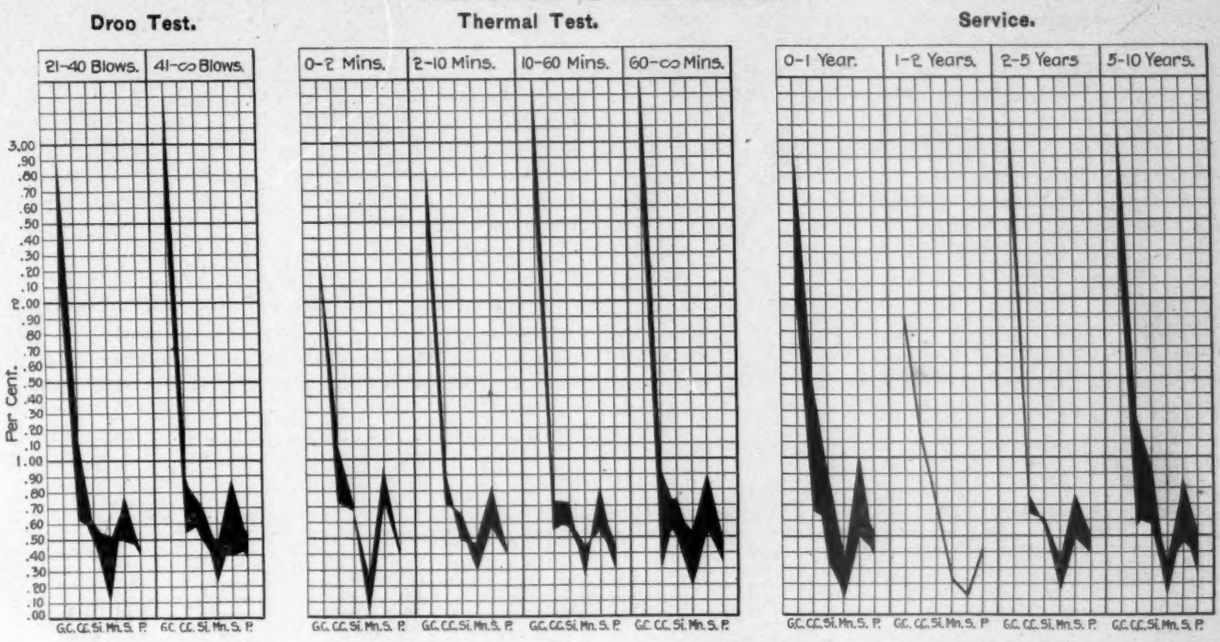


Fig. 1. Fig. 2. Fig. 3.

Note.—The sulphur is shown ten times too large.

CAST IRON IN RAILWAY PRACTICE.

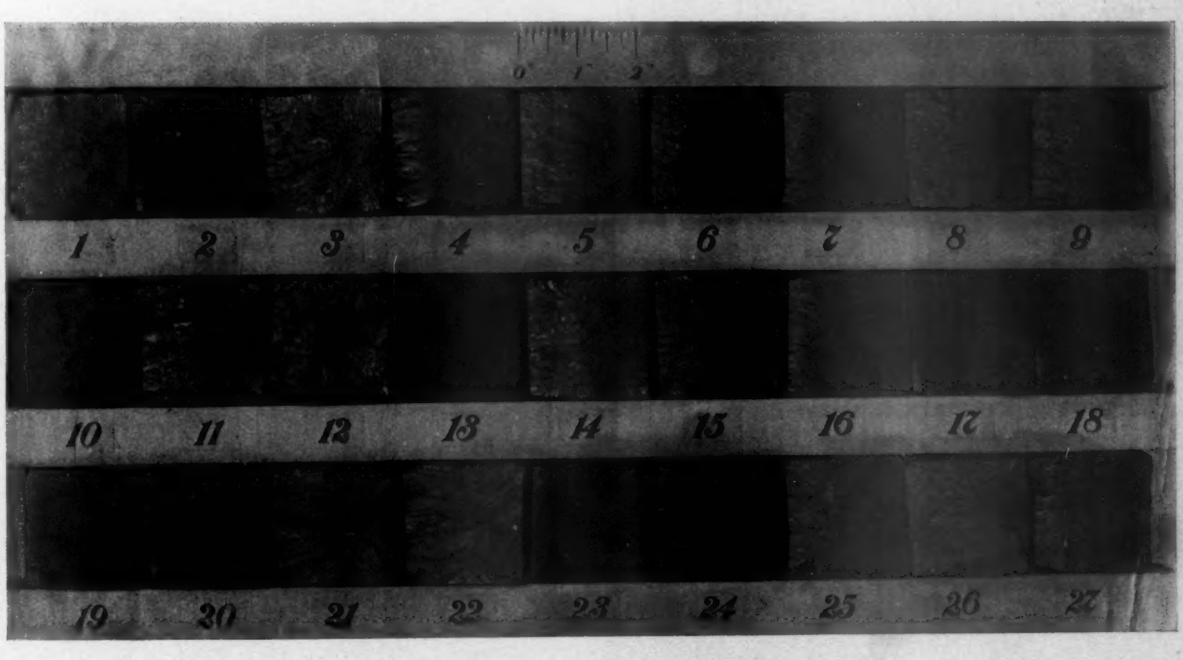


Fig. 4.—Showing Appearance of Fractures of Chilled Test Bars.

CAST IRON IN RAILWAY PRACTICE.

reason it is essential for the founder to be posted as to the properties of his output.

Manganese, more than any other one element, seems to be responsible for the capacity of the wheel to stand the thermal and drop tests. There is a great variation in the proportion of manganese even in different shipments of the same iron, and particularly is this true of scrap wheels.

In order to stand heating and blows, it seems essential that one-quarter of one per cent. of manganese should be present. Besides, there is always a loss of manganese in melting, so that a considerable quantity in the mixture is the more important. The practice of adding ferro-manganese to the ladle has been followed in many foundries with very satisfactory results.

Ferro-manganese, however, reduces the chill, and it is, therefore, necessary to use more iron of the high numbers in the mixture. It brings about this effect by changing some of the combined carbon into graphitic, thus softening the metal. This must all be allowed for in charging the cupola.

A set of experiments were conducted in order to determine this effect of ferro-manganese. A ladle full of the regular wheel mixture was used to fill smaller ladles containing different proportions of the ferro-manganese, of approximately the following analysis:

Analysis of Ferro-Manganese.

Manganese	80.02 per cent.
Carbon (combined)	6.24 "
Iron	13 32 "
Silicon	0.10 "

The resultant bars were then analyzed, with the following results:

Test of Wheel Iron with Ferro-Manganese.

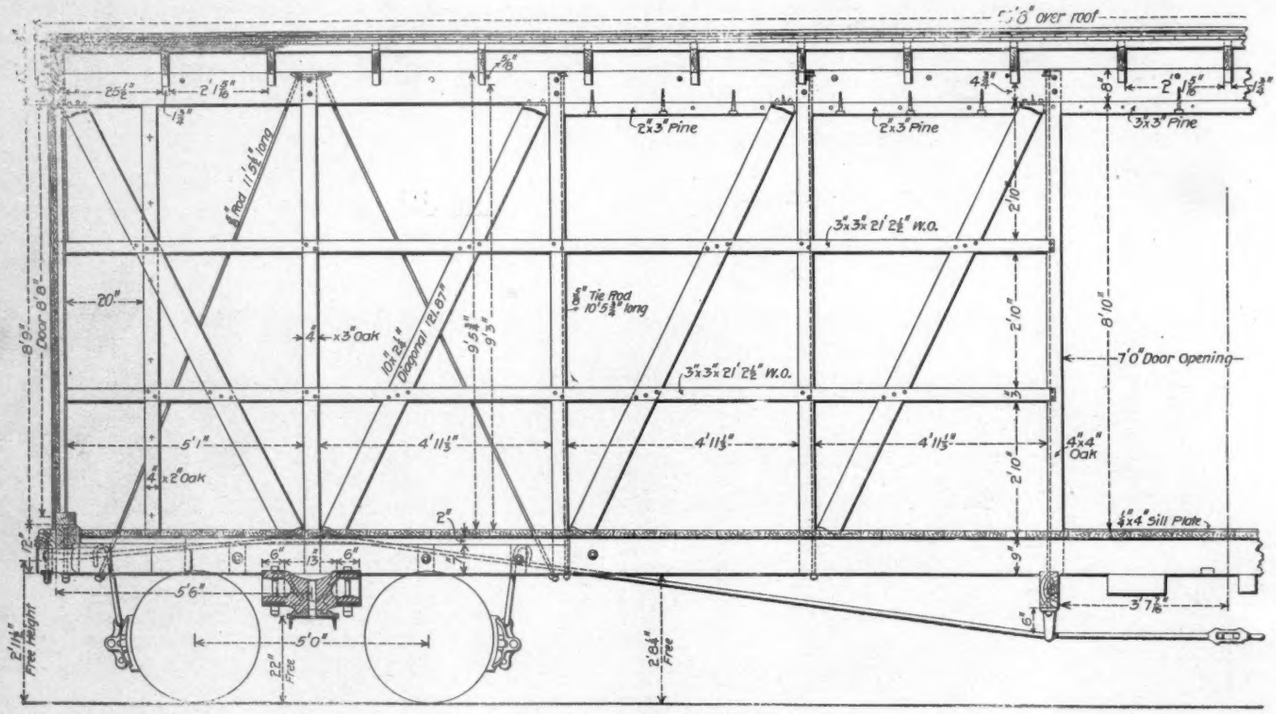
Ref. No.	Ferro-Man. added.	Fracture.	Chill.	Mn.	C. C.	G. C.
1	0.0	Light grey.	¾ in.	0.16 p. c.	1.13 p. c.	2.30 p. c.
2	0.2	Close light grey.	5/8 "	0.19 "	0.9 "	2.55 "
3	0.3	Close darker grey.	½ "	0.24 "	0.80 "	2.75 "
4	0.4	Close dark grey.	⅜ "	0.32 "	0.61 "	2.82 "
5	0.5	Open dark grey.	3/16 "	0.36 "	0.66 "	2.74 "
6	0.6	Open dark grey.	⅛ "	0.45 "	0.50 "	2.84 "

These tests run remarkably even (except No. 5, which is somewhat abnormal), and by their aid a more definite knowledge of the proper irons to charge into the cupola can be obtained.

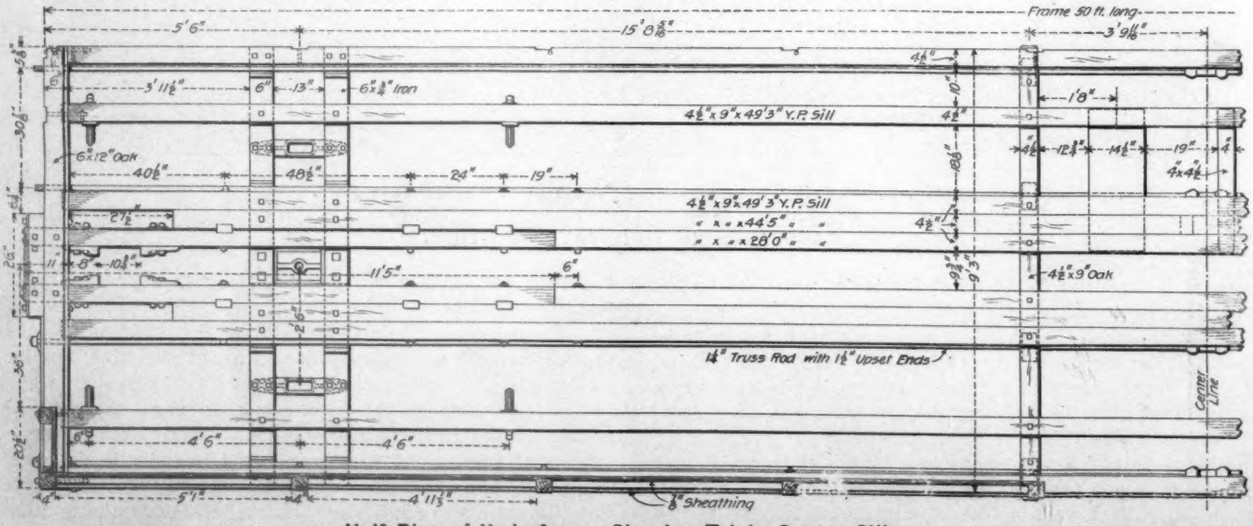
FIFTY-FOOT CARRIAGE CAR—C., M. & ST. P. RY.

Cars that may be used with equal facility for furniture or carriages have been designed and are now being built at the rate of ten per day at the West Milwaukee Shops of the Chicago, Milwaukee & St. Paul Railway. These cars, which are very large, are similar in some respects to the 46-ft. furniture cars, by the same road, which we illustrated in September, 1896, page 209, except that the carriage cars are larger and they have large end doors.

The arrangement of the under frame is unusual and worthy of note. The sills are all 4½ by 9 in. in section and are all in the same plane. There are the usual side and intermediate sills, and at each side of the center of the car three sills are placed face to face, making a solid mass of timber, consisting of six sills to receive the buffing and pulling stresses. The draft gear is attached to long 4½ by 7-in. draft timbers, which form a part of the two inside sills, as shown in the plan of the



Section Showing Side and Roof Framing.



Half Plan of Underframe, Showing Triple Center Sills.

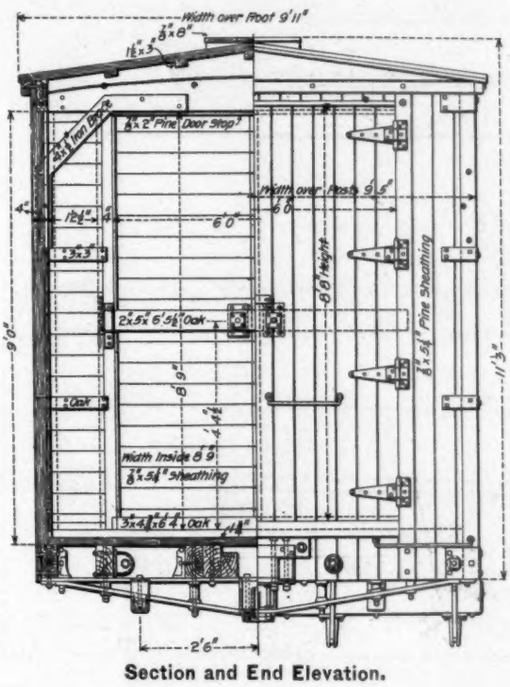
FIFTY-FOOT CARRIAGE CAR—C., M. & ST. P. RY.

floor system. The end sills are 6 by 12 in. and white oak. They are cut out at the center, not only for the coupler-shank, but also for the ends of the draft timbers. All of the bolts for the draft timbers are accessible from the outside of the car.

The body bolsters are double, of ¾ by 6-in. iron for the upper plate, and 1 by 6-in. for the lower plate. The center plate bearing is on a casting that spans the two trusses. The needle beams are 4½ by 9 in., of red oak, and there are four body truss rods.

The side and end posts are not mortised into the sills and plates but are gained lightly into these timbers and secured by horizontal bolts. The rotting of tenons and mortises is avoided and repairs are made easier by this construction. There are two white oak belt rails.

The end door is shown in the end view of the car. It is



Section and End Elevation.

in two parts, each hung on four heavy hinges, and the fastening is made by a 2 by 5 in. oak bar fitting into sockets on the end posts. The clear end door opening is 6 ft. by 8 ft. 9 in., and to compensate for the large opening at the ends, the upper corners are braced by ½ by 4 in. iron plates, welded twice, to give the desired form, and these secure the end plate to the corner posts. The side door openings are 7 ft. wide.

This car is 50 ft. 2 in. long over all, and 49 ft. 6 in. long inside. It is 9 ft. 5 in. wide outside, and 8 ft. 9 in. inside, the inside height being 9 ft. 5¾ in. The height from the rail to the top of the brake-staff is 13 ft. 11¾ in. The car body is high, and yet the total height is kept within bounds by the low trucks.

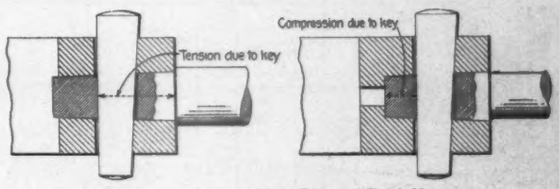
The trucks are of the Barber type, patented by Mr. J. C. Barber, formerly Master Car Builder of the Northern Pacific. They are substantially the same design as illustrated on page 210 of our issue of September, 1896, and the drawing presented at that time gives the dimensions for the present design. They have diamond frames, and the springs are seated on plates above the bottom arch bars and between the column guides. Caps are placed upon the tops of the springs, and rollers are put between these caps and the ends of the bolsters.

The surfaces which bear against the rollers are concave, causing a tendency to bring the bolster to its central position, and the side movements of the bolster are limited to 2⅛ in. by brackets secured to the top members where they stop excessive movements by striking the arch bars. The bolster has a nearly straight channel for its upper member and a ½ by 10-in. steel plate for the lower member; they are riveted together at their ends. The height of the truck from the rail top to the top of the upper arch bar at the center is 2 ft. ⅜ in.

The weight of the car body alone is 26,900 lbs., and with the trucks it is 37,900. We are indebted to Mr. J. N. Barr, Superintendent of Motive Power of the road, for the drawings.

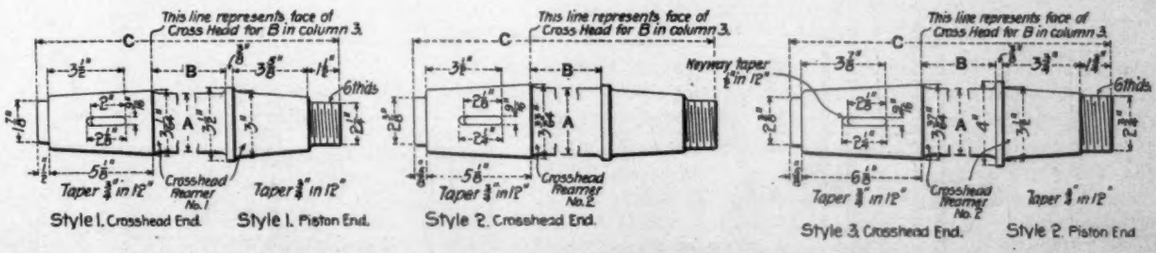
PISTON ROD ENDS.

In his article on piston rods in our issue of November, 1898, page 366, Mr. F. J. Cole presented diagrams illustrating some of the faulty methods of constructing piston rods, and the use of the form in which the end of the rod is turned down with a shoulder to bear against the cross-head is in such common use that it seems desirable that the improved practice should be brought to notice again. Piston rod failures are not uncommon, and the possible serious consequences of breakage emphasizes the importance of good design in this detail.

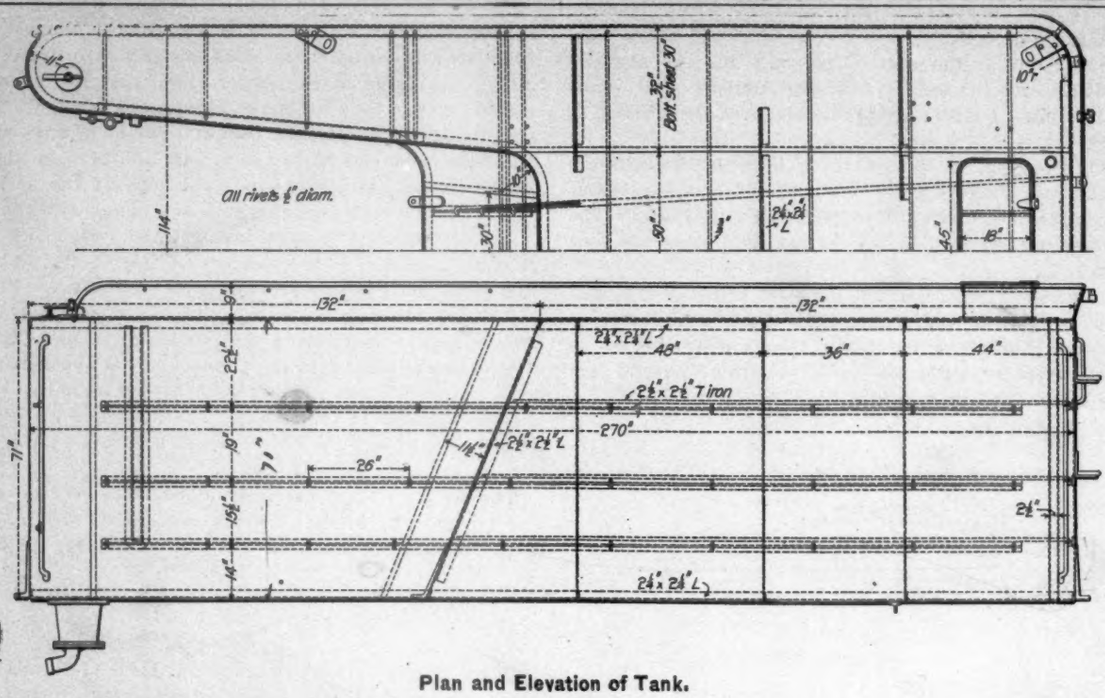


Stresses Caused by Piston Rod Keys.

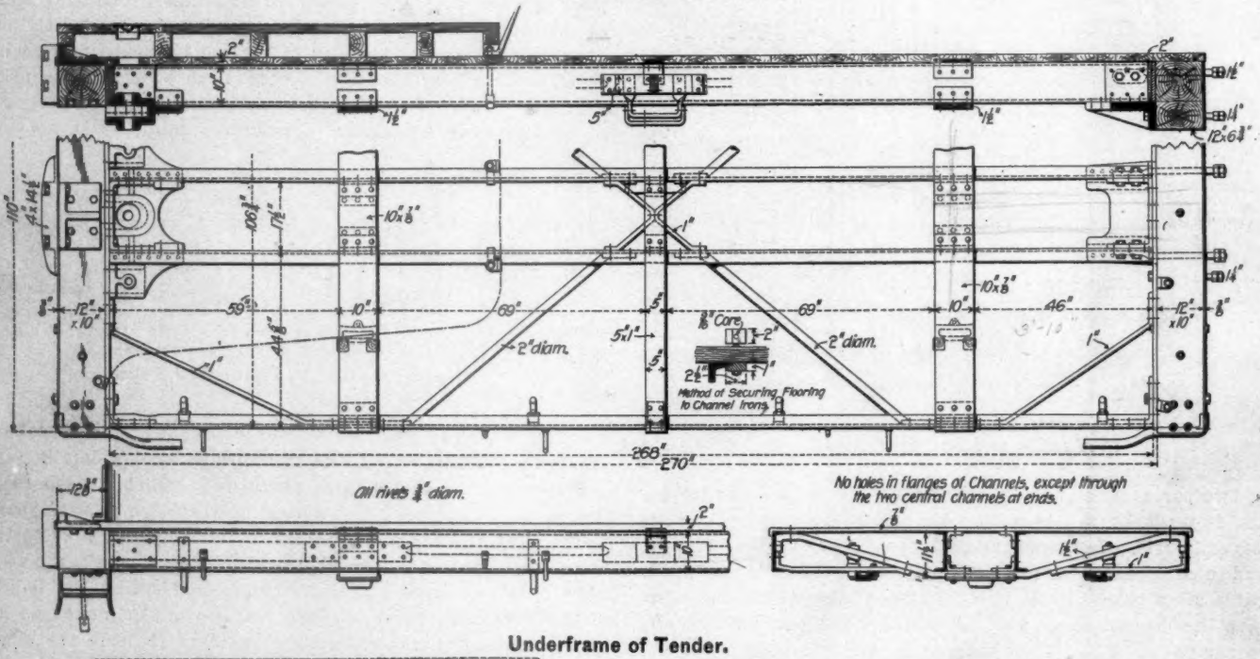
The engraving shows three piston rods which have been in use on the Chicago & Northwestern Railway for several years. These show the fits at both ends of the rods, but it is to the cross-head ends that special attention is drawn. These rods have only two sizes of enlarged ends and, while the length of the cross-head fit varies, two reamers are employed on all of the engines on the road. The sketches indicate the effect of the key upon the initial stresses in the cross-head fit, and it is clear that the enlarged ends by bottoming in the fit have the advantage of causing compression of the material at the end of the rod, as contrasted with the other form with the shoulder, in which the metal is stretched by the key in its weakest spot. This tension invites fracture, and a bad feature of the stress is that it cannot be measured or even estimated.


This line represents face of Cross Head for B in column 3.
Taper ¾" in 12"
Crosshead Reamer No. 1
Style 1. Crosshead End.
Style 1. Piston End.
Crosshead Reamer No. 2
Keyway taper ½" in 12"
Style 2. Crosshead End.
Style 3. Crosshead End.
Style 2. Piston End.

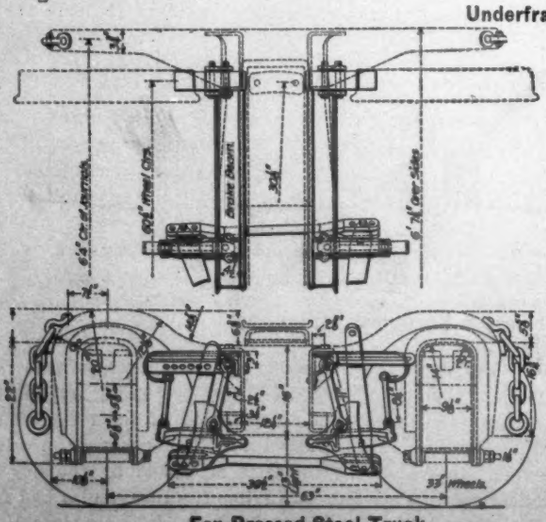
Forms of Piston Rod Ends Used on the Chicago & Northwestern Railway.



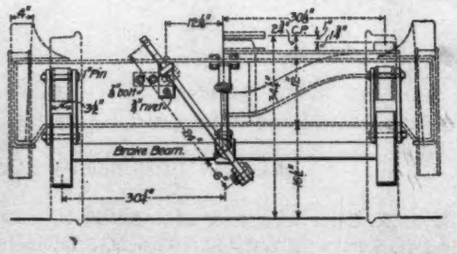
Plan and Elevation of Tank.



Underframe of Tender.



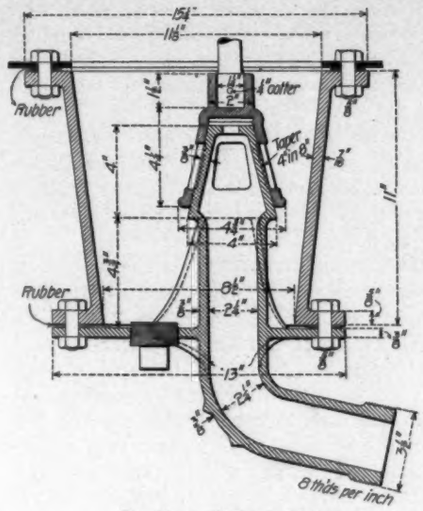
Fox Pressed Steel Truck.



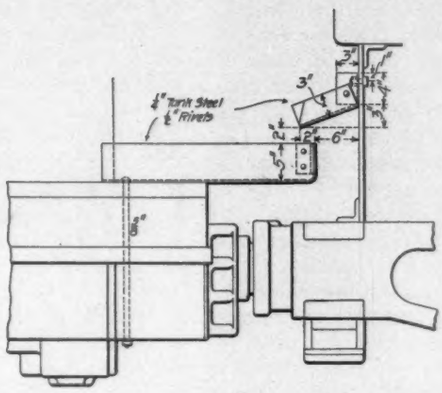
End View of Truck.

TENDER FOR HEAVY PUSHING LOCOMOTIVE.—LEHIGH VALLEY RAILROAD.

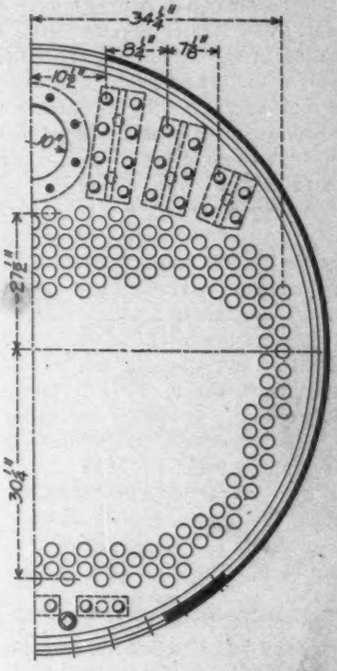
Capacity of Tank, 7,000 Gallons.



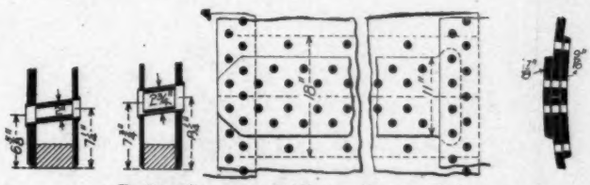
Section of Tank Valve.



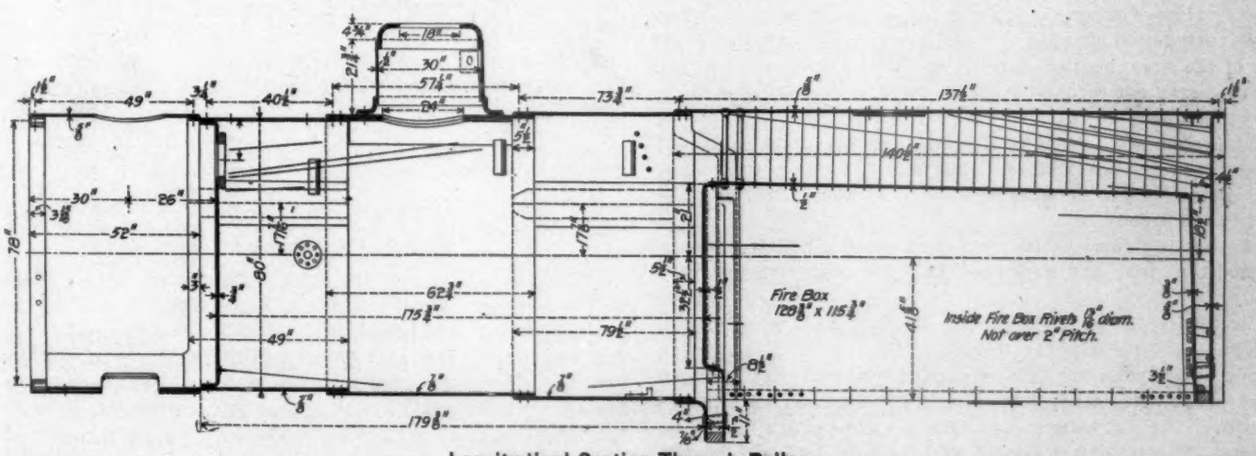
Coal Apron.



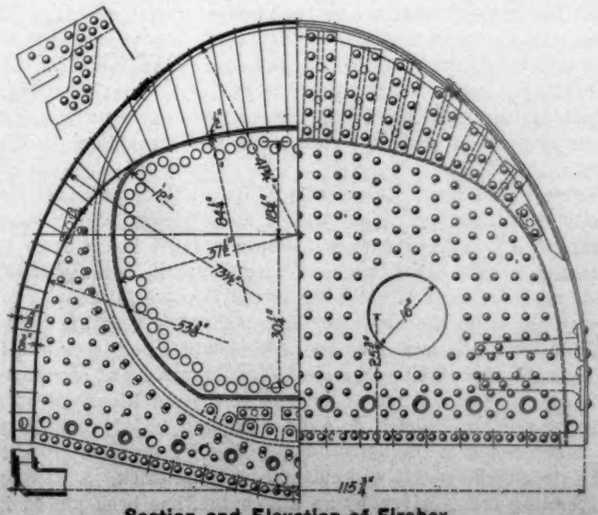
Section Through Boiler.



Boiler Seam and Water Space Tubes.



Longitudinal Section Through Boiler.



Section and Elevation of Firebox.

BOILER AND TENDER FOR HEAVY PUSHING LOCOMOTIVE, LEHIGH VALLEY RAILROAD.

The remarkable capacity of the mountain pusher locomotive built by the Baldwin Locomotive Works for the Lehigh Valley, illustrated in the "American Engineer" of December, 1898, page 395, is shown by the engravings of the boiler and tender. These are larger than any of which we have record. The boiler carries 200 pounds pressure and its heating surface is 4,105.6 square feet, the grate area being 90 square feet. The fact that the engine is a compound was commented upon last month, and while it is too early to predict as to the performance of the engine, we feel warranted in commending the boldness of the designers with reference to the immense heating surface and the compounding. In this case it is important from an operating point of view, as well as in economical operation, to provide large enough water carrying capacity to avoid stopping to fill the tank, and the features just mentioned ought to be very helpful in securing the desired result. The design exhibits unusual care in its plan and execution,

and it may have a marked influence on the heavy locomotive of the future.

Through the courtesy of Mr. S. Higgins, Superintendent of Motive Power of the road, we have drawings of the boiler and tender. The former requires little explanation, but attention is called to the large number of tubes, 511, and their length, 14 ft. 7¾ in. The firebox is of the Wootten type, for anthracite coal, and is 120 by 115 inches in size, the form being in compound curves struck from different centers. In this type of wide firebox boiler it is customary to make the sides flat with an arched crown, but in this design, which is like the Lehigh Valley standard, much enlarged, the firebox is made as nearly as possible a part of a true circle. This is done to increase the life of the staybolts on account of avoiding sudden changes of curvature and also, for the same width of firebox, the maximum firebox heating surface is obtained. The water spaces begin with a width of 3½ inches at the mud ring, except in front, where it is 4 inches, and they increase immediately above the mud ring. The disposition of the tubes is clearly shown. There are two firing doors 16 inches in diameter. We give details of the longitudinal seams. These seams are sextuple riveted and they have an efficiency of about 82 per cent. The smoke arch is a ⅝-inch plate, the body courses are ⅞ inch, the outside firebox sheets are ⅝ inch and the inside firebox sheets are ½ inch thick. The firebox sheets have two seams each. The mud plug holes at the corners are pressed outwardly to give good bearings for the plugs, this being a feature of the Baldwin boilers. The dome is on the second course, and has a pressed steel connection. There are 480 1⅛ inch and 1,255 one inch screw stays in this boiler. The diameter outside the first course is 80 inches.

The use of the auxiliary dome permits of attaching three safety valves without cutting the cup of the main dome. The short combustion chamber is found beneficial in prolonging the life of the flues, because it protects them somewhat from the air that may get through holes in the fire, and being short it is not necessary to stay the sides. Furthermore this shape of front firebox sheet is more flexible than the usual form and is less troublesome from cracking, and yet a new tube sheet may be easily put in when necessary without disturbing the rest of the firebox.

The heating surfaces insure good steaming and we are informed that with fine buckwheat coal the engine steams very freely.

TENDER

The tender carries 7,000 gallons of water and, when empty, weighs 45,250 pounds, the weight of the water alone being nearly 60,000 pounds. This is carried on two Fox pressed steel trucks with coil springs, 8 inches in diameter by 6 inches high over the journals, and 26 inch elliptic springs under the bolsters. The latter are double with 16 4 by 5-16 inch plates, and are designed to carry 7,500 pounds at a height of 9 inches over the bands. The wheels are chilled cast iron, 33 inches in diameter.

This engine has been in use about two months, and has given entire satisfaction. The object of the large capacity and some of the special features of the design are given in a letter from Mr. F. F. Gaines, Mechanical Engineer of the road, which we give in his own words. They present a strong argument for large tenders. Mr. Gaines says:

"I am aware of the fact that the use of large tenders has become a very important issue upon many roads, because the increased coal and water capacity often enable a train to save several hours delay by getting to a point where they will be out of the way of other trains; also in fast passenger service between competitive points, a question of a few minutes saved in running time is often of vital importance, and there is no question but that increased tank capacity will often save several minutes which would otherwise have been lost in taking coal or water.

"This tender was designed for use behind pushing engines on the grade between Coxton and Fairview (27 miles). The trains on this grade are frequently handled by one leading and two pushing engines, so the question of stopping to take water is of great importance. The new tender was designed after we had found from actual service what quantity of water would be required by a pushing engine to make the trip without stopping for water.

"In designing the tender several points were considered. All patterns and wearing parts were made interchangeable with the present standard tender. In designing the truck it was necessary to depart from the standard to provide for the greater journal load. In doing this we adopted the M. C. B. 5 x 9 inch axle, journal bearing, and wedge, as the possibility of their use in the near future under freight cars of large capacity is extremely probable.

"There are some points about the tender which, though standard on this road, may be of interest to others. The feed pipe valve drains the tank entirely, and in cases where every inch of water in the tank is needed, this construction is desirable. The inlet of the valve is so located that a residue is left for the accumulation of any dirt or ashes that may get into the tank. This accumulation can be removed whenever the engine is washed out by taking out the washout plug in the bottom of the valve chamber.

"The manhole is unusually large to allow free access of the water crane, without making it necessary to stop exactly in line with it. This design of manhole was adopted several months previous to the publication of an article on the subject in the "Railroad Gazette" of August 19th, 1898.

"The use of steel plates on the outside of the front and rear end sills saves many broken draft castings, and will prolong the life of the sills themselves. There are no holes in the flanges of the channels, except at the extreme ends, thus preserving their entire available strength.

"With fine coal, such as will be used on pushing engines, the tender apron saves its cost in a short time, by preventing the coal from working off the tender, when the tender has a full load."

TOPEKA SHOPS, ATCHISON, TOPEKA & SANTA FE RAILWAY.

Editorial Correspondence.

The chief buildings of the locomotive and car repair shops of the Atchison, Topeka & Santa Fe, at Topeka, are neither impressive nor modern, but the plant is an exceedingly busy one, and it is an excellent example of the good use of existing facilities. A generous policy is followed with regard to labor-saving conveniences. These appear very generally all over the works, and one who has not visited them for a couple of years will find much to be studied. When dies, formers and jigs are found distributed about a plant of this kind it is evident that many minds are active in co-operative efforts to reduce the cost of work and replace the labor of men by the use of machinery. This is exemplified by a very modest, but exceedingly business-like, corner of one of the machine shops, which is devoted to the production of labor-saving appliances. Four lathes and several benches are kept busy here in this way.

Several machine tools recently added to the plant are especially worth noting. The first is a double spindle Newton lathe, which will swing work 26 and 44 inches in diameter by 7 feet in length. This is a convenient machine because of the wide range of work it will take, and it is powerful enough for heavy pieces on the upper centers, and yet is very handy for lighter work. It is a good tool for terminal points, where it is desirable to combine in a small shop a variety of capacities in a single lathe. Another good machine is a Richards' open side planer, by Pedrick & Ayer, having a bed 24 feet long. A rotary shear in the boiler shop is found convenient in cutting circular holes. It will cut plate ⅝ inch thick. A new set of bending rolls, driven by an air engine, has been placed in

a new building near the large blacksmith shop. This machine will bend sheets 12 feet wide and 1⅛ inches thick. It was furnished by Wickes Brothers, Saginaw, Mich. A large No. 5 double bulldozer by Williams, White & Co. has been placed under the same roof with the bending rolls. The work for this machine is heated in a large oil furnace near by, and we found 150 truck arch bars of 1¼ by 4-inch iron being bent to shape in eight hours at the time of the visit. The waste heat from this furnace on its way to the chimney flue passes through an oven or box in which all of the case hardening work of the plant is done. Experiments are now being tried in the use of "scintilla," a case hardening compound, furnished by Messrs. Paul, Martin & Co., of No. 101 Aldersgate St., London, England. The claims made for it are uniformity and rapidity of case hardening, and an experiment shows that a depth of 1-32 inch of hardening has been obtained in about five hours, while a depth of 3-32 inch has been secured in about 12 hours. By ordinary methods, it had not been customary to get over 1-16 inch in from 12 to 14 hours. If further results are equally satisfactory it will be possible to do the case hardening during the regular working hours of the shop instead of always requiring night work, which is the present practice. We are informed that this material has been used successfully on driving axles of the Great Western Railway of England, where a depth of 1-16 inch is regularly obtained in 12 hours.

CASE HARDENING

A new arrangement of oil furnace has been devised here, in which the flame is carried entirely across the furnace and upon its return it comes against the iron to be heated, the spray being obtained by a blower blast. In one of the forge shop furnaces the stock for forging car center pins is heated at the rate of 100 pins per hour, the furnace taking nine at a time. These are made in a forging machine, located at the furnace, at the rate of a thousand per day. Oil furnaces are in general use about the shops, and also in the outlying building, where the brake work for cars and the bolt work is done. It has been found advantageous to provide an oil supply at each furnace in order to keep somewhat of a check upon the consumption. This is done by means of an elevated tank near each group of furnaces, and these are filled from the large supply tanks by aid of air pressure and a system of underground piping.

OIL FURNACE

The substitution of crushed steel abrasive for emery for the grinding in of valves and steam tight joints was found satisfactory. Two sizes of the abrasive known as Nos. 170 and 120 are used, the former for brass and the latter for cast-iron. This abrasive does not crush or pulverize, and besides cutting quicker than emery, there is less waste. With a small rotary air motor running at 170 revolutions per minute, a steam joint is ground in 20 minutes. This material has replaced all but flour emery; it is so economical that an amount that may be held on a five-cent piece is sufficient for grinding a steam pipe joint. The material is known as diamond crushed steel abrasive, and is furnished by the Pittsburg Crushed Steel Co., of Pittsburg, Pa.

The new car repair shop, which is about 200 by 800 feet in size, is an excellent investment, and the work that was formerly done out of doors is now done under this roof for protection of the men against the weather. The repair work goes on steadily the year round, and it is believed that the building more than pays for itself in a year. One track in this building is devoted to new work. About 500 cars were built last year, and about that number will be built this year. It is the policy of this company to build a new car to replace every one destroyed. This large building is well supplied with connections for air piping, for various portable tools and for the air jacks with which the cars are raised and lowered. Air connections are provided at every alternate line of posts. Two men raise and lower all cars, as well as remove and replace their trucks. Two other men handle the pneumatic tools for boring holes. The circular saws driven by compressed air in this shop are very convenient; there are several small portable saw tables driven by 5-inch single cylinder air motors, and an emery wheel for sharpening chisels and similar tools is driven in the same way. A very ingenious device is a circular saw combined with a motor, mounted in a frame, for the purpose of cutting off the ends of the roof boards in place. This is pushed along the edge of the roof like a lawn mower, and it cuts very rapidly. The shop is provided with cross tracks, and instead of turn-tables a large number of air jacks are provided, the plungers of which come up under the small push cars loaded with material, and by taking a bearing on a casting under the center of the car it may be raised so that the wheels will clear the track, whereupon the jack becomes a turn-table.

A great deal of attention is now being paid to standardizing the storehouse stock, with a view of reducing the amount of material carried. A complete catalogue of all the material used about locomotives and cars is being made, and the idea is to reduce the number of sizes to the minimum. This applies to all kinds of stock, and by distributing copies of the catalogue the ordering of odd and unusual sizes is to be prevented. This is a large undertaking and is being carried out by Mr. Hancock, with the assistance of an apprentice. In the storehouse the variety of malleable iron fittings for locomotives at once attracted attention. A large number of parts usually made in brass or wrought iron are found to be equally satisfactory in malleable iron, and the smoothness and accuracy of the castings is remarkable. Among these are handles for globe and other valves, with the spindle holes cored so nicely as to avoid all necessity for machine finishing. Oil cups, reverse lever latches, brake wheels and other parts are very successfully cast in malleable iron. The castings seen were made by the Dayton Malleable Iron Co., and when such malleables are available there is no reason for continuing the use of brass.

The use of pneumatic tools in these shops is extending, and the present capacity of the compressing plant, which is 1,200 cubic feet of free air per minute, is barely sufficient for the requirements. The large Rand compressor furnishes 1,700 cubic feet, and a 14 by 42 inch cylinder, which was connected in tandem arrangement to the machine shop engine in 1891, furnishes about 400 cubic feet per minute. The air piping system extends more than a mile from the compressors. At a distance of a half mile away rails are cut and drilled by pneumatic power. In the shops a number of 300-pound steam hammers are operated by air. It is said that they are quicker in movement and there is no trouble from condensation. In the boiler shop we found the last two of 12 new boilers built this year, and the riveting has practically all been done by air. Locomotive tanks, holding 5,000 gallons, are machine riveted throughout, except the upper connection at the back of the coal space. By the use of compressed air in the sand tower, sand is elevated and delivered to locomotives by the "hostlers," saving about $3.75 per day. In one of the shops we found a frame for heading ¾-inch rivets by means of pneumatic hammers. The frame has a gap of 10 feet, and is made of two 5-16-inch plates, braced with angle irons. Sand blast apparatus is used in cleaning paint from tanks, and a 4,000 gallon tank is cleaned all over in four hours. The sand blast outfit is mounted on a two-wheeled hand wagon. The receptacle for sand is a large auxiliary reservoir, which is filled with sand twice for a tank. The weight of the apparatus empty is 443 pounds, and the weight of the sand is 330 pounds. Air at from 80 to 90 pounds pressure is used.

While it is probably true that some of the operations effected by pneumatic power at these shops might be more economically performed in most places by some other power, it is also true that the convenience and ease of distribution of compressed air are advantageous, and while small air motors may not be theoretically efficient, their extensive use is justified by the cheapness in cost of production of the power, coal only being used under the boilers at night and the major portion of the supply being obtained from burning refuse lumber from the car department.

We are indebted to the courtesy of Mr. John Player, Superintendent of Machinery, and Mr. George A. Hancock, Assistant Superintendent of Machinery, for an instructive and enjoyable visit to these shops.

COMMUNICATIONS.

SHORT SMOKE BOXES FOR LOCOMOTIVES.

Editor "American Engineer":

I notice the illustrated article upon "Short Smoke Boxes for Locomotives" appearing in "The American Engineer" for December. It is an interesting subject to any one who has had the experience of changes in various forms of smoke boxes which from time to time have appeared and had their day, and the remarks introducing the article, with its reference to the Master Mechanics' Association Report for 1898, page 112, with extract therefrom, I consider fairly states the smoke-box situation as it exists to-day.

You refer particularly to Mr. J. Snowden Bell as deserving of credit for persistent presentation of his design and its successful use in a number of instances. My agreement with this view of the matter is the occasion of this letter, as I happened to be well informed as to his efforts in the past and aware of the success reached by his design of smoke box and front-end appliances used therein. He has pressed this plan for consideration from a time when the current set strongly in favor of long smokes boxes and their internal fixtures. The writer was not carried away with the first extension smoke box by J. H. Congdon (the original Jacob of this design), Superintendent of Machinery of the Great Western Railway—not enough, in fact, to try it—but he did profit by the hint given, and extended the smoke box in some engines then being built by several inches—I believe, four inches—from the very short boxes then used. Mr. Congdon did not obtain entirely satisfactory results with his design, and abandoned its use when leaving the Great Western to become Superintendent of Motive Power of the Union Pacific, and the long front, with here and there a spasmodic attempt by others, for quite a time made no great headway. Smoke boxes generally, however, were made somewhat larger as a result of his experiment.

Later on the extension front, as it was called, again made appearance in connection with the straight open stacks, and in some instances also with improved internal appliances of smoke box, coupled with improved furnace arches resting upon water tube supports, and with arch brick perforated with holes for the consumption of gases. The success due largely to these helped the introduction of long smoke boxes and open stacks generally.

In his contention for short boxes Mr. Bell has not antagonized any of these where they are in use, but persisted in the shortening up of the long boxes and the use therein of his design or arrangement of nettings, plates, lifting pipes, height of exhaust nozzle, etc., for success.

The plan shown in Fig 4, on page 393 of your December, 1898, issue, of the Baltimore & Ohio design, has met very nearly my idea of what this arrangement ought to be. I notice, however, in the experience had with Fig. 6 plan, Wisconsin Central Railway, there is complete success in free steaming, and, even when observed at night from the locomotive, a freedom from spark emission of dangerous nature.

When coal is fed to the furnace in proper quantity at a time, and of a proper size, good results will usually follow the use of ordinary devices in the prevention of smoke and spark emission. I was at one time so impressed with this—when in charge of locomotives of a Western railroad—that I appointed one of the best firemen as foreman fireman and instructed him in his duties, and the engineers and firemen were to observe his instruction to them. In addition, Sinclair's book on "Combustion of Coal" was supplied to them, and, altogether, it was found to be a satisfactory experiment. Ordinarily, however, the calmness or indifference of fuel users must be guarded against, and it is my opinion, based upon experience, and wide observation that the Bell design of short smoke box, taken complete in its details, will come as near doing this as is desired, with the straight open stack.

You have drawn upon the experience of Mr. J. H. McConnell, Superintendent of Motive Power of the Union Pacific Railway, as related to the 1898 Convention of Master Mechanics' Association, to illustrate your position as stated, and there is no doubt of correctness in this instance. It would, however, be interesting if Mr. McConnell should make a good service test of the Bell design of smoke box in connection with the diamond stack which he is now using on engines, with the view of eliminating all sparks in the use of the Wyoming lignite coal.

GEO. W. CUSHING,

308 Western Union Bldg., Chicago, Ill., Dec. 12, 1898.

BROOKS CONSOLIDATION LOCOMOTIVE.

Oregon Railroad & Navigation Company.

In November of last year the Brooks Locomotive Works built three consolidation lcoomotives for the Oregon Railroad & Navigation Company.

These engines weigh 136,200 lbs. on drivers and the weight of the engine in working order is 154,000 lbs., the total of engine and tender being 252,000 lbs. They have 19 and 30 inch cylinders, 10 inch piston valves and the Player patent Belpaire boiler, with supplemental steam dome. The boiler is 64 inches in diameter and has a total heating surface of 2,162 square feet with a firebox 114 by 42 inches, giving 32.4 square feet of grate area. The firebox is above the frames.

There are several features in the design of the details that are unusual and some are new. The frames are narrowed down at the cylinders, where they take the form of slabs. The spring rigging is "over-hung," with the equalizers between the upper and lower bars of the frames, and links are used between the ends of the springs and the equalizers. The first pair of driving wheels are equalized across the engine by a spring with 6 by ½ inch leaves, and by this spring they are equalized with the pony truck. The crosshead is "H" form, and very light for an engine of this weight. The piston rods, also the valve stems, are extended. The driving wheels have cast steel centers and all of the tires are flanged. The link lifters are combined in a single arm of cast steel placed at the center of the width of the engine, and each link has a suspension bar from the lifter arm. This arm projects through the guide yoke and is seen in the photograph. The reach rod is also a departure from common practice, being a 2 inch extra strong pipe with ends welded in. The cab is of sheet metal and its floor is flush with the deck and the running boards. Among the details of the running gear we notice that the main crank pins are enlarged in the wheel fits. They have a diameter of 7 inches at the inside rod bearing and 7⅜ inches in the wheel. This is commendable, and it might be well applied to all the pins. With the exception of the main pins the crank pins are hollow. The following table gives the chief dimensions of the engine:

Gauge	4 ft. 8½ in.
Kind of fuel to be used	Bituminous coal
Weight on drivers	136,200 lbs.
" " truck	17,800 "
" total, engine	154,000 "
" of tender, loaded	98,000 "
" " engine and tender, loaded	252,000 "

General Dimensions.

Wheel base, total, of engine	23 ft. 2 in.
" " driving	14 ft. 6 in.
" " total, engine and tender	51 ft. 8¾ in.
Length over all, engine	38 ft. 1⅝ in.
" " " total, engine and tender	60 ft. 11⅞ in.
Height, center of boiler above rails	8 ft. 11 in.
" of stack above rails	14 ft. 10½ in.
Heating surface, firebox and arch pipes	204 sq. ft.
" " tubes	1,958 "
" " total	2,162 "
Grate area	32.4 "

Wheels and Journals.

Drivers, diameter	55 in.
" material of centers	Cast steel
Truck wheels, diameter	30 in.
Journals, driving axle, main	8½ by 11 in.
" " " front, back and intermediate	8½ by 11 in.
" truck	5½ by 10 in.
Main crank pin, size	6¼ by 6 in.

Cylinders.

Cylinders	19 by 30 in.
Piston rod, diameter	4 in.
Main rod, length center to center	125 in.
Steam ports, length	21 in.
" " width	2 in.
Exhaust ports, least area	54 in.
Bridge, width	3½ in.

Valves.

Valves, kind of	Piston
" greatest travel	7 in.
" steam lap (inside)	1⅛ in.
" exhaust clearance (outside)	⅛ in.
" lead in full gear	1-16 in. negative

Boiler.

Boiler, type of	Player, Belpaire
" working steam pressure	200 lbs.
" thickness of material in barrel	⅝ in.
" " " tube sheet	¾ in.
" diameter of barrel	64 in.

Crown sheet stayed with	Direct stays
Dome, diameter	30 in.

Firebox.

Firebox, length	114 in.
" width	42 in.
" depth, front	76 in.
" " back	69 in.
" thickness of sheets	⅜ in. and ⅝ in.
" mud ring, width	Front, 4 in.; back, 3½ in.; sides, 3½ in.
Grates, kind of	Cast iron, rocking
Tubes, number of	286
" material	Charcoal iron
" outside diameter	2 in.
" length over tube sheets	13 ft. 2¼ in.

Smoke Box.

Smoke box, diameter outside	67 in.
" " length from flue sheet	60 in.

Other Parts.

Exhaust nozzle, single or double	Single
" " variable or permanent	Permanent
" " diameter	5 in., 5 3-16 in., 5⅜ in.
" " distance of tip above center of boiler	1 in.
Netting, wire or plate	Wire
" size of mesh or perforation	2¼x1¼ and 2½x2½
Stack	Steel taper
" least diameter	15⅞ in.
" greatest "	18⅞ in.
" height above smoke box	38 in.

Tender.

Type	Eight-wheel
Tank capacity for water	4,500 gals.
" " " coal	10 tons
Type of under frame	Steel channel
" " springs	Double elliptical
Diameter of wheels	33 in.
" and length of journals	4¼ in. x 8 in.
Distance between centers of journals	6 ft. 3 in.
Diameter of wheel fit on axle	5⅜ in.
" " center of axle	4¾ in.
Length of tender over bumper beams	22 ft. 1½ in.
" " tank	19 ft. 6 in.
Width " "	9 ft. 10 in.
Height " " not including collar	46 in.
Type of draw gear	Standard M. C. B.

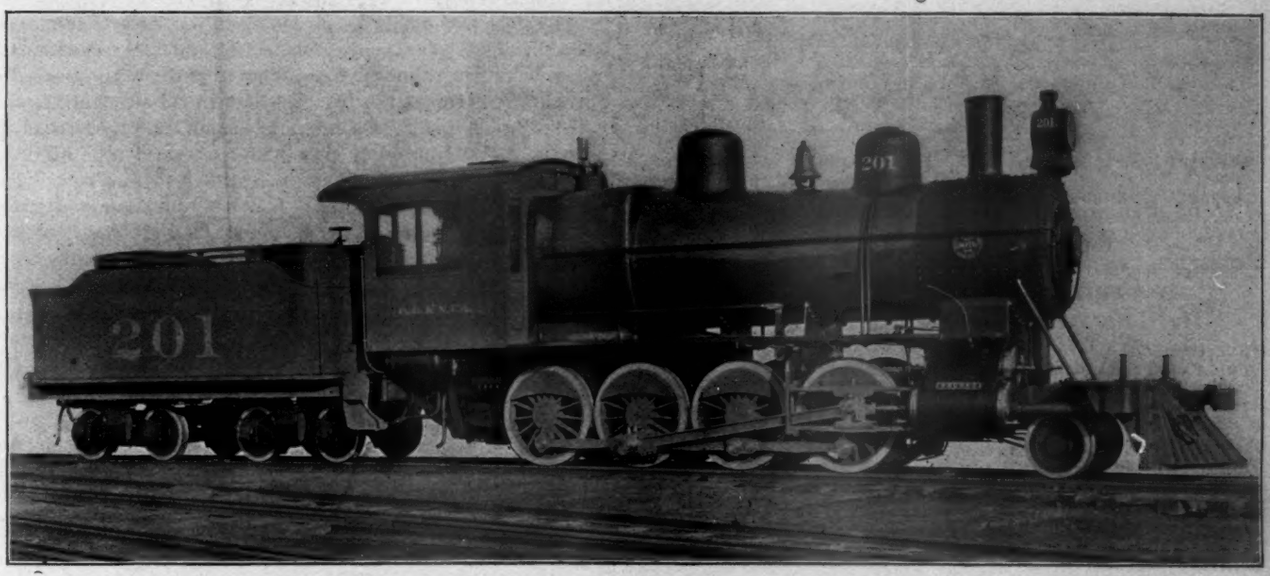
Special Equipment.

Sight feed lubricators	Nathan No. 9
Safety valves	Kunkle
Injectors	Monitor Simple No. 8 and No. 9
Springs	French

THE CARNEGIE STEEL COMPANY TO BUILD CARS.

There are good reasons for believing that the Carnegie Steel Company will undertake the building of steel cars and that a large plant will be erected near Homestead, Pittsburgh, for this purpose. The "Iron Age" says:

"After testing the experimental cars for about two years the management have become so thoroughly satisfied of their superority over wooden cars that it was resolved to erect very large steel car building shops, including a new plate mill, wheel foundry and axle plant, so that every part of the car can be finished by continuous progress out of the raw material produced by the Carnegie Steel Company. The property just purchased is 4,000 feet long and at least 1,500 feet will be used for the shops, the intention being to begin at the mill where steel plates come out of the rolls and put out the finished cars at the other end. All the shop machinery will be run by electricity, and it is needless to say that every known device to economize at every point will be adopted. Rolled shapes will be used, as these have proved stiffer than the pressed shapes employed in steel cars. It is stated that the Carnegie Steel Company, Limited, can roll shapes on the mills as redesigned as cheap as the straight plates. The capacity of the plant will be 40 cars per day. The enterprise is in no wise antagonistic to the Schoen Pressed Steel Company; on the contrary, the two concerns will work in harmony. It is believed that no one concern can possibly meet the coming demand for steel cars and it is regarded as doubtful whether the two plants can do so. We understand that it is the policy to concentrate the steel car business in Pittsburgh, if possible."



Brooks Consolidation Locomotive—Oregon Railroad & Navigation Company.

DR. C. B. DUDLEY AT PURDUE.

The first lecture of the Purdue Railway Course for the season of 1898-9 was given on Nov. 29 by Dr. Charles B. Dudley, Chief Chemist of the Pennsylvania Railroad. Dr. Dudley's subject was "The Relation of Chemistry to the Railroad." The speaker first gave some interesting figures on the amounts of money spent by the railroads for various materials, which very forcibly illustrated the immense importance of the departments of chemical and physical testing and inspection. He said that the purchasing agent of the Pennsylvania Railroad spends from $17,000,000 to $20,000,000 a year, and of that amount about $5,000 goes for rubber bands, $7,000 for lead pencils, $1,000 for pins, $5,000 for ink, $2,000 for toilet soap, $1,000,000 for lumber, $60,000 for hose, and called attention to the very interesting fact that it costs nearly as much for stationery with which to carry on the business of the road as it does for iron. The duties and responsibilities of the inspector were then described and his work illustrated by reference to numerous actual cases.

Dr. Dudley took up the subject of specifications, and showed how they are built up and the methods of obtaining the information from which they are compiled. As an illustration he gave in detail the Pennsylvania Railroad specification for car axles. These specifications contain not only information for the guidance of the manufacturer, but for the purchasing agent, inspector and tester as well.

He showed that it was the duty of the chemist not only to write specifications and test materials, but to investigate special problems on a great variety of subjects, and related many instances from his own broad experience which showed the wide range of information and ingenious application of new methods which have been called into play in the solution of these various problems which have arisen from time to time. The personality of the speaker and his wide experience combined to make the address one of unusual interest and profit.

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The substantial recognition which this paper is receiving in this and foreign countries is extremely gratifying to the management and staff. A large number of prominent men have been added to our subscription lists during the past year, and many commendatory letters have been received from old subscribers, indorsing our efforts to publish a journal that meets their approval. Our purpose is to make each issue better than the previous one.

The significance of the placing of orders for 20 locomotives for the Midland Railway in the United States is not yet clear, but the promise of very early delivery probably has some influence. These will be built in lots of 10 each, by the Baldwin and the Schenectady works. The explanation offered for ordering here is that the English works are crowded.

The views of Sir W. H. White on engineering education, printed elsewhere in this issue, supported, as they are, by rare experience and opportunities for studying the effects of education, are commended to the consideration of young men contemplating engineering work, and of those who have to do with their guidance. The necessity for preparation for education appears to merit thought, and also the importance of the place, in the order of time, given to practical experience.

In his article on the design of parallel or "side" rods in this issue, Mr. F. J. Cole gives a valuable table of moments of inertia of different sections of rods varying from 3 to 6 in. deep. These are original with Mr. Cole and were worked out specially for this article. We desire to direct special attention to Mr. Cole's tables and diagrams presented in earlier articles. They afford means for saving a great deal of labor by designers and others who are examining or improving their practice. The operating officers of the future will demand locomotives that will not break down. Failures of locomotives on the road are now generally followed up closely and a great deal of attention is given to the details of design in order to make each part strong enough. Those who are following up these matters, as well as the designers of new equipment, find Mr. Cole's articles helpful and suggestive.

Not the least important principle that Mr. Cole brings out is the necessity for sizes of parts that will keep the fiber stresses within safe limits. It has been said that time spent upon designing details of locomotives was wasted, because if the bearing areas are sufficient to prevent heating the strength is sure to be ample. This has been true in the past, and it may even now apply to light engines, but it does not hold good in the heavy engines of present practice. It is evident that locomotives are continually becoming more difficult to design as the requirements become more and more exacting, and the thorough methods of most foreign locomotive men in looking after details may well be copied here. This suggestion is supported by the table of fiber stresses in crank pins and driving axles, derived from foreign locomotives given by Mr. Pomeroy in this issue. It is clear that comparatively low-fiber stresses in these parts are more general in the engines given in this record than will be found in those of this country. The relative number of failures representing the different conditions is not known, and while it may be said that locomotive parts are subjected to so many stresses that are not subject to measurement or calculation as to upset all computation, there is every reason for providing for all of the known factors and leaving good judgment to attend to the unknown.

The present tendency is to relieve enginemen of all care of the machinery, and soon they will do little except to run the engines. Formerly they were required to attend to many adjustments and were held responsible for "their own engines" as regards many minor repairs; they were also required to report defects that they could not fix, and this they were much better able to do before the days of pooling. If engines are to be kept in condition for their best service something will need to be done to enable enginemen to report intelligently upon necessary repairs and adjustments. When they did more work upon the engines they knew better when that work was necessary. On one extensive road this tendency is offset by the traveling engineers, who spend a great deal of time in instructing the younger men as to the proper working of the engine, as well as in reporting defects, and the results are gratifying. Every improvement that will reduce the amount of running repairs, and especially those that will prevent breakdowns, mean cheaper operation for the same reason that pooling does. Moreover, a locomotive large enough to cost $15,000 must be kept at work or it represents no saving over lighter and less costly ones.

That there is something to be gained from heating feed water by steam after it has done its work in the cylinder is generally admitted, and it is easy to see that much of the heat ordinarily thrown away in the exhaust may be saved by passing it into the feed water. It is generally considered that the saving may be easily calculated and that it is represented by the heat units actually gained by the feed water. This difference of temperature is only a part of the gain, because by heating the feed water the entire contents of the boiler are in a more favorable condition as to its heat-absorbing ability. A boiler seems to work more economically when it is not required to heat as well as evaporate water. Feed water heating is as old as the steam engine and was used by Watt. It has always been considered desirable and is more properly appreciated now than ever before. Two articles in this issue furnish reasons for looking into the subject carefully.

An idea which has much to recommend it is being worked out on the Atchison, Topeka & Santa Fe in holding the division superintendents responsible for the conduct of business on their divisions or districts. They are required to follow up the work of other departments in their territory and are practically general managers of the portions of the road under their charge. An excellent result of this plan is that all subordinate officers are brought to see the relations of one department to another in a way which is likely to broaden their ideas and enable them to contribute their part of the operation of the road intelligently with a view of the important ultimate object of increasing net earnings. This has a tendency to prevent any one department from considering that it has any interests of its own aside from the general good of the whole. It may be said that division superintendents cannot be expected to understand the use of fuel and other similar details and that they should not be held responsible for them. Here is the nub of the whole idea. The best use of fuel can be obtained only through the co-operation of the operating officers. The same principle applies in other matters, and if this theory is carried out the division superintendent will be a very important officer and not merely a good train master or dispatcher.

The difference between the operation of the Diesel motor and the Otto gas engine does not appear to be generally understood, if we are to judge by remarks recently heard in a conversation on internal combustion engines. The first stroke of the Otto gas engine draws a mixture of air and gas into the cylinder, the second stroke compresses it, at the beginning of the third stroke it is exploded, and during the third stroke the piston is driven forward as a result of the explosion, while the fourth stroke expels the burned gases from the cylinder. The operation of the Diesel motor is entirely different. The first stroke draws air into the cylinder, the second compresses it to about 600 lbs. per square inch, at the commencement of the third stroke oil is forced into the cylinder against the high pressure by means of a small auxiliary pump driven by the engine and is immediately exploded by the heat generated by the compression, the piston is driven through the third stroke by the force caused by the burning oil, and the product of combustion is expelled during the fourth stroke. The air compressed by the pump referred to is also used in starting the engine, and this gives the Diesel motor an advantage over others by being always ready to start. The advantages of this motor have been summed up as follows: Simplicity, specially as regards regulation, automatic ignition of the gas without requiring any mechanism for this purpose, regularity of operation under varying loads, good design of oil injecting device, whereby the oil is completely consumed, extreme cleanliness, and the ability to start instantly at any time. The consumption of petroleum, according to Professor Schroter, given in a paper last year before the Institution of Civil Engineers (England), is 0.524 pound per brake horse-power and 0.396 pound per indicated horse-power per hour.

The superiority of steam boiler construction in England, when compared with that of this country, is commented upon by the "Mechanical Engineer" of Manchester, England, in connection with the proposed standard specifications of the American Boiler Manufacturers' Association, the prevalence of punched holes or rivets being one of the features of our practice that is surprising. This critic is rather severe, but it must be admitted that there is justice in such remarks as the following: "Any engineer, however familiar with good English boiler work and methods of construction, must feel, on perusing the standard set forth by American makers, that it permits, and in a measure officially recognizes, methods and practices which no first-rate maker on this side would care to defend." Notable exceptions may be quoted, but the association is on record as to what must be considered common practice in this country. The type of boiler has much to do with the degree of care required to make it tight and safe, and the rather general use of large and thick shells in England demands more careful work than our smaller and thinner ones, but this is merely a defense and not a justification. Greater care in boiler making will pay for the additional cost, and if stationary practice is brought up to the high standard of locomotive work in this country our contemporary will have reason to commend rather than criticise. Well-supported opinions of this kind cannot but improve our boiler making.

NECESSARY IMPROVEMENTS IN CAR CONSTRUCTION.

In an admirable paper recently read before the Western Railway Club, Mr. F. M. Whyte, Mechanical Engineer, Chicago & Northwestern Railway, showed a number of possible improvements in the under-framing of car bodies which should have the attention of car builders. Mr. Whyte assumes that the bolsters should be stiff enough to carry the whole load on the center plates without deflecting enough to bring the side bearings together. He remarks upon the efforts, some of which have failed, to get sufficient strength without exceeding proper limits of weight, and makes the following proposition: That the present general practice of framing cars may be changed so as to distribute the load to the bolsters, and particularly to the body bolsters, in a way that will be more favorable to the bolsters.

The difficulties presented by the truck bolster are not as great as with the body bolster, because the former is not restricted within such narrow limits of depth as the latter, and it is also much shorter. The two must be considered together, however, and the author of the paper remarks upon the practice of using substantial truck bolsters under very weak body bolsters, and says that cars at present are generally weakest at the body bolsters. There would be no difficulty if the load could be transmitted to the bolsters directly over the center plates, and the author shows how the usual arrangement of sills, needle beams and truss rods may be changed to transmit the loads more favorably.

The stresses from the side sills are most unfavorable, and those from the center sills are most favorable, therefore the center sills should be made to transmit as much and the side sills as little as possible. The intermediate sills are a part of the floor, and their location does not affect the proportion divided between the side and the center sills, which is the important factor. The location of the truss rods does affect this, however, and he suggests placing them upon each side of and close to the intermediate sills. It is obvious without calculation that this arrangement will bring the heavy stresses nearer the center plate than the usual plan with two of the truss rods at the inside faces of the side sills. Mr. Whyte then suggests that if the center sills rest upon the needle beams it is possible that some of the load that ought to be carried by the center sills directly to the center of the bolster may be transmitted through the needle beams to the truss rods and to the bolster at a considerable distance from the center,

which is, of course, objectionable. If the center sills are not allowed to touch the needle beams, and if the latter members receive the loads from the side and intermediate sills only, the bolsters must be more favorably loaded, especially if the outside truss rods are brought inside of the intermediate sills. Another and better method is to "locate a truss rod either inside or just outside of each center sill and another truss rod at the inside of each intermediate sill, or even closer to the center of the bolster." This necessitates stiffening the needle beams to prevent them from bending between the side sills and the outer truss rods.

That the form of the upper framing has to do with the failure of bolsters has not escaped notice in the paper, and it is shown that the diagonal bracing of the ends of the car should be inclined at such an angle that it will carry the thrust to the center sills instead of to the side sill. If the braces are used in the customary way, tension rods may be put in parallel to the braces, and they will transmit some of the load from the side sills to the end plates, and through the end posts to the center and intermediate sills.

The desirability of always carrying the load upon the center plate instead of purposely allowing the side bearings to run in contact and provide friction reducing side bearings is debatable, but Mr. Whyte has contributed very valuable and logical suggestions that should be considered, whether side bearings are purposely allowed to come into contact or not. A stiff bolster, carrying the load upon the center plate, seems to have the greatest number of advantages, and Mr. Whyte's plan will be useful to get the strength without too great weight. We have shown the importance of improved side bearings, and it is evident that they must often come into contact. This and the increasing weight of the cars, are reasons why some friction reducing form should be used.

It seems necessary to remark that center plates are now very heavily loaded, and that they must be made larger or relieved in some way from the heavy pressures now used. This has had very little attention, and it is more important with every increase in the capacity of cars.

NOTES.

The plans for the four new monitors for the U. S. Navy have been changed, and as adopted by the Board of Construction they will have single turrets, each containing two 12-inch guns, but the length of the ships is to be increased 27 feet, which allows 200 tons more coal to be carried. The sum of $103,145 has been agreed upon by the contractors as compensation for the additional requirements above the prices already established.

A convenient valve for pneumatic track sanders, devised by Mr. Theo. H. Curtis, of the Nickel Plate, is described in a recent issue of the "Railway Master Mechanic." It is mounted upon the top of the Westinghouse engineer's brake valve and the advantage it offers is that of convenience in application of the sand, either simultaneously with or independent of the air brake. The pneumatic sander has two valves, one for ordinary use and the other for emergency applications of the brakes.

The preparation of waste for lubricating the journal boxes of freight cars has received careful attention by many master car builders. Mr. J. J. Hennessey, of the Chicago, Milwaukee & St. Paul, has fitted up an old box car body at West Milwaukee with oil tanks and soaking racks, using no free oil in the journal boxes. The waste is soaked in a tank of oil for 36 hours. The surplus oil is then drained out upon sloping racks for four or five hours and the oil is used over again for more waste. The waste becomes thoroughly soaked in the oil and the result is better lubrication, fewer hot boxes and a great saving of oil. The amount of oil used for cars that are repaired and those built at these shops in one-fifth of that formerly required when the oil was poured into the journal boxes. The old car is heated by steam to a temperature of 70 degrees.

An 8-inch Gatling one-piece cast steel gun was tested at Sandy Hook Dec. 15, and the results are reported to be satisfactory. Dr. Gatling expects this gun to be made at about one-half the cost, and in much less time than the built up guns now used. The steel is given a whirling motion in pouring, for the purpose of carrying impurities toward the center, from which they may be afterward removed by boring. The casting is made with a large sink head to give a compression to the material, and the inside is cooled first in order to give an initial tension to the outside portions. The reports of the trial show that the gun withstood a pressure of 37,000 pounds per square inch.

Signaling systems on railroads in which the colors of lights permit of mistaking crossing gate or other lights for fixed signals are not uncommon, in spite of the fact that the dangers are known. The expense and bother of changing a system of lights is sufficient excuse for continuing their use until some accident occurs. Green has been selected as the safest signal for "all clear" indications, and yet many roads stick to white lights. The Whittenton Junction accident on the New York, New Haven & Hartford, which resulted from an engineer's mistake in taking a white gate light for a clear signal from a semaphore, has led to a decision to change to green for "all clear" on that road.

The shells used by the United States Navy, the guns for firing them and the powder charges for each are given in the following table, for which we are indebted to "Engineering News":

	Shells.				Guns.			Total cost of
Designation—	Diam. Inches.	Wt. Lbs.	Lgth. Inches.	Chge. Lbs.	Wt. Tons.	Lgth. Feet.	Chge. Lbs.	firing once.
1-pdr	1¾	1	3⅝	200*	100 lbs.	5	—	$1.12
3-pdr	1⅞	3	6½	900*	500 lbs.	7	—	—
6-pdr	2 3-16	6	8⅝	1,400*	920 lbs.	9	—	5.70
4-in	4	33	12¼	2	1½ tons	14	14	—
5-in	5	50	16¾	3	3½ tons	17	30	33.00
6-in	6	100	20¾	4½	6 tons	21	50	40.00
8-in	8	250	22¾	11	15 tons	29	115	65.00
10-in	10	500	30	20	28 tons	31	240	—
12-in	12	850	36	40	45 tons	37	425	—
13-in	13	1,100	42	50	60 tons	40	550	296.00

*Grains.

Note—For 13-in. armor piercing projectiles the total cost of firing is $588.00.

Comparative costs of the three principal systems of street car operation are given by the "Railroad Gazette" from the report of the Metropolitan Street Railway of New York for the year ending June 30, 1898. The car miles were: Cable, 11,991,000; electric, 7,110,000; horse 15,995,000.

	Cable.	Electric.	Horse.
Maintenance of way	$3.54	$0.33	$0.72
Maintenance of equipment	0.94	0.83	0.39
Power	2.02	1.70	6.40
Transportation	7.78	6.15	8.49
General expenses	2.07	1.22	1.87
Totals	$16.35	$10.23	$17.87

If the cable car miles had been run at the cost of the electric working, the saving would have been $745,840 in the year, or 4 per cent. on $18,646,000. If the horse-car miles had been run by electricity at the cost as given in the table, the saving would have been $1,220,000, or 4 per cent on $30,500,000. This is the best commentary we have seen upon the advantages of electric traction.

Since the discussion of the subject of broken stay bolts before the Master Mechanics' Association in 1897, the stay bolts of locomotive boilers have come in for more attention than formerly. It will be remembered that Mr. T. A. Lawes at that time showed conclusively that partially broken bolts could not be detected by the hammer test; in one case where three inspectors in turn examined a firebox and found four broken stay bolts the drilling test disclosed 46 others partially broken. The best practice now is to drill the ends of all stay bolts or use hollow stays, but too much reliance should

not be placed upon this means for automatically detecting broken bolts; these holes must be cleaned at frequent intervals or they are useless. Our attention was called to this fact a few days ago by a Superintendent of Motive Power, who had found in cutting out a firebox between 150 and 200 stay bolts wholly and partially broken, and, although these had telltale holes in the ends, none had shown any signs of leakage.—"Railroad Gazette."

FIBER STRESS, DRIVING AXLES AND CRANK PINS, FOREIGN PRACTICE.

By L. R. Pomeroy.

A careful study and analysis of American practice as regards the dimensions of crank pins and driving axles, from the standpoint of fiber stress, has led the writer to examine foreign practice, with a view of ascertaining how their methods compare with ours. Research in both cases has been confined to designs where the power of the piston is delivered on the outside bearing of the pin, as is the case with moguls, 10-wheelers and the so-called Atlantic types of locomotives. In this case the question governing the design is one of fiber stress, and not the bearing surface. Because, if the dimensions are large enough to bring the fiber stress down to a safe minimum, the bearings will be plenty large enough from the bearing standpoint, other things being equal.

Such a comparison of foreign locomotives, however, is rather hard to get, for the reason that there are so few types of engines used abroad with outside cylinders, where the conditions are fairly comparable, and by dint of careful searching among the proceedings of foreign technical societies and the foreign technical press the writer succeeded in finding 28 cases, which are represented in the annexed table. This table is also interesting from the fact that it shows incidentally the form of pins and driving axles. The conventional drawing of the driving axle illustrates the prevailing practice abroad of increasing the size of the wheel fit, and also the form of collar used inside of the driving box. It is also quite common to introduce a collar on the opposite side of the box, which is fitted into a counterbore in the wheel fit. The method of calculating the fibre stress is according to the plan illustrated on page 211 of the June, 1898, issue of the "American Engineer."

FIBER STRESSES, DRIVING AXLES AND CRANK PINS, FOREIGN PRACTICE.

	R. R.	Type of Locomotive.	Cyl.	Boiler Pressure.	Main Crank Pin. f	D	L	d	l	Fiber Stress.	Main Driving Axle. A	B	C	D	E	F	G	Distance from Center Line Through Cyl. to Center of Journal.	Fiber Stress at E (lbs.)
			INS.	LBS.	INS.	INS.	INS.	INS.	INS.		INS.	INS.	INS	INS.	INS.	INS.	INS.	INS.	
1	Great Northern, England	Atlantic	19x24	175	7	6	3	5	5	12,900	7¼	9		9½	8½	8½		16¾	15,200
2	N. S. Wales (Beyer, Peacock & Co.)	4-coupled	21x26	160	6½	6½	5¾		6	17,900	6½	10¼		9	8½	7½		20¼	21,300
3	Mexican Ry. (Neilson & Co.)	8-coupled.	18½x26	175	6	5½	4½	5	4½	19,000	6½	9		8¾	8	7½		17¾	19,000
4	" "	8 "	18x26	165	6½	6	5¾	5	4½	15,800	6½	9	¾	8¾	8½			18¾	14,500
5	Mercy R. R. (Kitson & Co.)	6 "	19½x26	150	6¼	5¾	4½	4½	5	18,700	6½	10¼		9	7½	7¼		18⅝	22,000
6	North London (J. C. Park)	6 "	17x24	160	5½	5	5	4¾	4	20,00	6¼	8		8	7¼	7		17¼	18,000
7	Sou. of Italy (Neilson & Co.)	6 "	20¾x26	117	6.69	5.9	4	4.8	5	16,300				8.61	7 48	7.48		19	25,800
8	Highland Ry. (Sharp, Stewart & Co.)	6 "	20x26	170								7		9	8			18	21,000
9	Indian State Ry. (Neilson & Co.)	8 "	20x26	180	6½	6½	5¾	5½	5	17,000	6⅛	10		9	8¼	8		20⅛	22,000
10	Gt. Northern (P. Stirling)	1 pr. drivers	18x28	160							7¼	8	¾	9½	8½	8¼	9¼	13¾	6,530
11	Soudan Mil. Ry. (Neilson & Co.)	8-coupled	17x23	160										7½	7	6½		16½	19,700
12	Cape Gov. Ry. (Dübbs & Co.)	6 "	17x26	160		4.75	4	4.25	5	22,000				7.5	7	6.5		17	20,700
13	Grand Central (Belgium)	6 "	18.9x23.6	142		5.1	4.3	5.1	5.1	20.000		9.45			6.69			18.9	27,700
14	Northern (France)	4 "	16.5x23.6	142							6.69	9 44	0.78		6.69			16.3	18,300
15	Prussian State (Compound)	6 "	18.1 x 26.8 / 23.6	180							7.08	9.44		7.48	7.08	7.08		18.1	26,000
16	Jura Simplon (Swiss)	4 "	16.14x24.1	150	5.3	4.9	3.34	3.9	4.1	13,700	6.14	6.49	0.98	7.08	6.49	6.49		15.19	20,000
17	" "	6 "	17.7x25.59	150	6.10	6.10	3.74	3.93	4.32	9,700	6.89	9.84		8.07	7.48	7.08		18.1	18,000
18	Central "	6 "	19.68x24.8	150	6.69	5.50	4.30	4.50	5 28	19,000	6.69	9.80		7.87	7.87	7.87		18.9	19,560
19	" "	6 "	17.7x23.6	150	6.49	5.31	3.39	4 72	6.48	15,800	6.41	9 84		7.08	7.08	7.08		18.5	20,900
20	Union "	6 "	17.7x25.59	150	5.90	5.51	3.74	4.74	4.32	13,300	6.89	9.84		8.07	7.48	7.08		18.1	18,000
21	" "	8 "	19.68x21.26	150	5.90	5.51	3.93	4.30	4.21	16,700	5.90	7.87		6.49	6.49	6.37		16.29	29,000
22	" (Compound, Swiss)	6 "	17.7 x 25.19 / 25.59	170	5.90	5.51	4.88	4.70	5.90	20,000	7 32	10.24	0.78	8.07	7.48	7.08		19.50	21,600
23	St. Gothard "	8 "	20.47x24	180	6.29	5.90	4 88	5 10	4.30	19,800	7.08	9.44		8.26	7.87	7.87		18.22	24,000
24	" "	8 "	20.4x24	149	6.29	5.90	4.68	5.90	3.90	15,600	7.08	9.44		8.26	7.87	7.87		18.22	20,600
25	Imperial Japanese	6 "	13x18	140		4	4⅜	3¼	3¾	18,000	5¼	6½		6¼	5¼	5		14¾	20,900
26	Finland State Richmond Comp'nd	6 "	15¾ x 25 / 20⅛	170		5	4⅜	4½	4⅜	17,800		7⅞		6½	5⅜	5½		16⅛	27,000
27	Eastern (France)	4 "	18.5x25.98	170	6.50	6.30	5 43	5.70	4.9	14,500	7.08	9 05		8.66	7.67			20.5	23,500
28	Northern "	8 "	20.86x25.59	142	6 89	6.69	4 21	5.78	5.5	11,800	7.28	9.80	1.4	8.19	7.87	7.67	9.84	20.0	21,800

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. NINETEENTH ANNUAL MEETING.

The annual meeting of this society was opened in New York Nov. 29, President C. W. Hunt in the chair, the first session being devoted to the address of the President. This was a tribute to the engineer, and gave a broad view of his duties, responsibilities and pleasures. At the next session the routine business was disposed of. The committee to confer with the Master Mechanics' and Master Car Builders' Associations on the subject of standard pipe unions, had been obliged to ask for more time. The council had considered a change in the requirements for admission of members on account of the existing rule which gives the veto power to a small and diminishing proportion of the membership. It had also appointed a committee to report on the standardization of methods of testing steam engines. The fireproofing tests had been discontinued by the committee having it in hand, because of lack of funds.

A communication was read from the Institution of Civil Engineers, England, offering the courtesies of the house of the Institution to the members of the American Society who may visit the Paris Exposition in 1900. The finances of the society were shown to be in a satisfactory condition, the total receipts for the year being $32,406.87, the disbursements $31,755.82, and the amount due the society $3,364.67. The first committee report was that on the testing of materials, and Mr. Henning stated that the society was now represented by membership in the International Association.

The professional reports and papers are too long to be presented in our pages, even in abstract, and as they may be had in printed form from the secretary for a small expense, we shall refer to them but briefly.

Revision of the Code for Boiler Trials.—This is a very voluminous report, and the additions to the previous work consist in including the use of recent forms of calorimeters, and covering the analysis of flue gases and stating the efficiency of the boiler. The report will be acted upon at the next meeting of the society.

Strength of Wheel Rims.—Mr. A. K. Mansfield showed in this paper that instead of adding strength to a wheel the ribs that are often put along the edges of the rims are a source of weakness. A deep rib at the center of the wheel was preferred.

Bursting of Small Cast Iron Flywheels, by C. H. Benjamin. —This paper recorded tests by the author on 17 small model wheels. Rim joints between the arms were considered serious defects and flywheels with solid rims, with the usual number of arms and proportions commonly used by engine builders were

considered safe at a rim speed of 100 feet per second, providing good iron was used and cooling stresses avoided. The best of the discussion was by Mr. John Fritz, who stated that there was no defense for a burst flywheel. He referred very modestly to his experience, in which he had designed a large number of flywhels and none of them had failed. He preferred a hollow rim and hollow arms, and did not believe in using metal where it added weight without giving additional strength. The rim joints were made half way between the spokes and were held by links, the slots for which were compensated for by adding material to take the place of that displaced for the links. True running was important, and a wabbling wheel was a dangerous one.

Improvements in Steam Boilers and Their Settings, by W. B. Le Van.—This was a description of a horizontal fire tube boiler, especial care being taken to secure the proper admission of air and to utilize as much of the shell as possible in the form of heating surface. The discussion was almost savage, taking the ground that the ideas were old. One member thought that the author was courageous to champion the fire tube boiler at this late day. The author replied that because a thing was not new it was not necessarily bad.

Use of Steam by Anthracite Mining Companies in Pennsylvania, by R. V. Norris.—This is a record of wastefulness of steam that is remarkable and instructive. The author describes, by aid of indicator diagrams, the condition of the engines at these two mines, and relates that by such work as repairing the steam piping and setting valves he was enabled to save enough steam to permit of shutting down twenty boilers at one of the plants and six boilers at the other.

Valve Gear of the Willans Engine, by John Svenson.—This is a complete and valuable description of the Willans engine, including the central valve gear. The discussion brought out the fact that although the rotative speed of these engines is high, being from 300 to 500 revolutions per minute, the short stroke keeps the piston speed down to about 500 feet.

Cooling Tower and Condenser Installation, by J. H. Vail.—This is a description of a cooling tower added by the author to an electric lighting plant in order to increase its capacity without adding to the boiler power. The plant had 27 boilers, 48 inches in diameter, and 20 feet long, and by the addition of the condenser and cooling tower the power was increased by 1,000 horse-power, and there was now steam to spare.

Methods of Testing Indicators, by D. S. Jacobus.—The author directs attention to faulty methods of testing indicator springs, among which is the comparison with the mercury column. He illustrates apparatus for testing that will give the same lines in ascending as in descending pressures when the instrument is in proper condition.

Variations of Belt Tensions with the Power, by W. S. Aldrich.—The paper is a study of the experiments made some time ago by Messrs. Wm. Sellers & Co., and presented in a paper to the society by Mr. Wilfred Lewis. The results of the experiments are plotted in curves and a formula is devised to accord with them.

Calorific Power of Weathered Coals, by R. S. Hale and H. J. Williams.—This is a record of comparisons between samples of coals that had been exposed to the weather for eleven months and samples of the same coals that had been sealed up during that time. The tests by the Williams bomb calorimeter showed that the coals lost about one-half of 1 per cent. of their calorific power in that time by weathering.

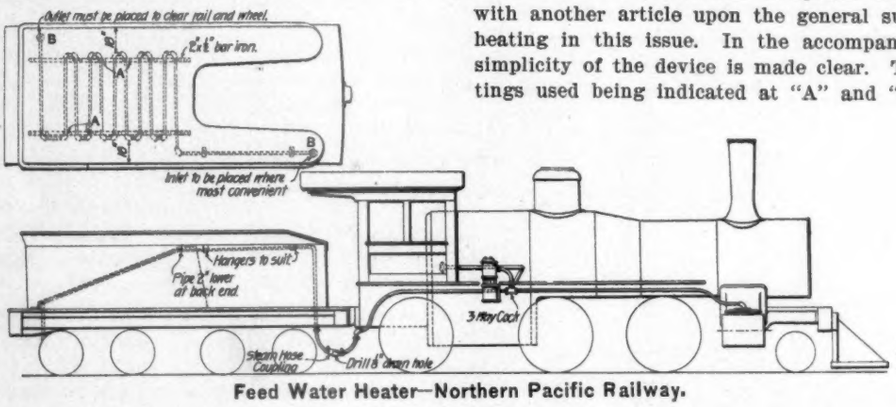
Mechanical Plant of a Modern Office Building, by W. H. Bryan.—This is an interesting record of the design of the entire mechanical plant of a large retail store, and gives the author's figures and specifications for the work. It is a valuable record for those who have work of this character to do, and brought out considerable discussion. A great deal of data are given and the author's methods are outlined. The variety of subjects arising in this problem is striking.

Flow of Steam in Pipes, by R. C. Carpenter and E. C. Sickles.—This paper describes experiments carried out at Cornell University, and from them formulas are worked out to fit several sizes of pipe. The discussion took the form of criticism of the work because the tests were too few to justify such formulas.

The meeting was successful, and while the papers were, as a rule, not remarkable, the discussions were valuable. The next meeting will be held in May, 1899, at Washington, D. C.

HEATING FEED WATER FOR LOCOMOTIVES.

At a recent meeting of the Western Railway Club, Mr. E. M. Herr, formerly Superintendent of Motive Power of the Northern Pacific, gave some interesting and valuable information in regard to the heating of feed water for locomotives by use of the exhaust steam from the air-brake pump. We show the construction of the tank heater referred to, and reproduce Mr. Herr's statement, which is of special interest in connection with another article upon the general subject of feed-water heating in this issue. In the accompanying engraving the simplicity of the device is made clear. The only special fittings used being indicated at "A" and "B." The former is a ⅜ by 1½-inch clamp, and the latter is a flanged coupling. Mr. Herr's remarks were as follows:



Feed Water Heater—Northern Pacific Railway.

"The last eighteen engines that we built for the Northern Pacific under my jurisdiction had pipes leading from the exhaust side of the air pump through the tank, and in order to get rid of any possibility of oil giving trouble in the tank, the pipe did not deliver the steam into the tank; the water of condensation dropped upon the roadbed after passing through the coil of pipe in the tank. The arrangement of this pipe was as follows: It was brought up on the right-hand side, right next to the tank valve and vertically to the top of the inside of the tank. From this point it extended toward the back and downward in a gradual slope, and zigzag across the tank the width of one water leg until it finally passed through the tank near the back. As the water in the tank got lower, the heating surface exposed to it was continually reduced, and the amount of heat going into the water was correspondingly less; consequently, there was less liability that the water be heated to too high temperature. When the tank was full, of course the water came in contact with more heating surface and more heat was absorbed by it. If the engineer ever did get caught with water so hot he could not work the injector, it always occurred with the right-hand injector first, because the pipe went into the right side, entering near the feed valve opening. In such a case he could always readily start the left-hand injector, because in the left leg of the tank there is no heating pipe, and there is a considerable reservoir of cold water which could be used in an emergency, and would supply cold water enough to be used by the left injector until the next water station was reached. I was surprised to find that

there was very little difficulty of this kind on these passenger engines; there were sixteen of them hauling through passenger trains, doing pretty heavy service, and the engineers ran their exhaust in the tank continuously, very seldom having to divert it on account of the water getting too hot; that happening only in very hot weather. In the Fall and Spring, and, of course, throughout the Winter, there would be no occasion for them to change the exhaust from the tank. This is a very important factor in saving of fuel, as can be very clearly seen when one considers that, as I believe the authorities estimate for every 11° rise in the temperature of feed water there is a saving of about 1 per cent. of coal used in the generating of steam. This is a theoretical consideration, but I thought we could notice in the fuel consumption and in the steaming of the engine in bad weather a very undoubted and practical advantage. In practice the temperature was rarely raised above 90°, and 90° is about the limit at which an ordinary injector will handle water. I did a great deal of experimenting with different makes of injectors to find out which would handle the hottest water. If, as seems to be the case, one can effect a saving of 1 per cent. of coal for each 11° increase in temperature of feed water by reason of using the exhaust steam, we certainly should get that injector which will handle feed water at the highest temperature possible, and obtain this economy. By experimenting, I found one injector that would handle feed water at a temperature of 124°."

LOCOMOTIVE DESIGN—THE WORKING STRENGTH OF MATERIALS.

By F. J. Cole, Mechanical Engineer Rogers Locomotive Works.

PARALLEL OR SIDE RODS.

The consideration of what design is the most suitable for a part or member of a machine is often of as much importance as the material from which it is made. A notable instance of this may be cited in the case of the parallel or side rods coupling together the different pairs of driving wheels.

Fifteen or twenty years ago rods of rectangular form were in general use; some were of uniform section and others deeper and thinner in the middle, tapering down to the normal size at the ends next the crank pins. The long rods of this style used on eight-wheel engines having two pairs of driving

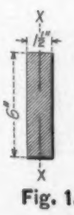


Fig. 1.

Fig. 2.

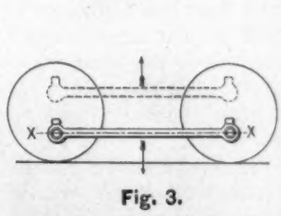


Fig. 3.

Fig. 4.

wheels and a four-wheel truck—commonly known as the "American type"—were continually breaking, the position of the fracture generally lying in the central portion of the rod. Imagine the rod divided into three equal parts, then the majority of fractures would occur somewhere in the central part, towards the ends. Increasing the size of the rods decreased slightly the number of breakages. Making the center deeper and thinner was a much greater improvement, but was only a step in the right direction.

The general opinion was that fractures were liable to occur whenever the pedestal wedges were improperly adjusted or when, from other causes, the engine got "out of tram," as it is commonly called; that is, increasing or decreasing the distance between the centers of the driving wheels until they measured or "trammed" more or less than the length between the centers of the crank pins. This would throw a great strain on the frames, rods and crank pins, as the engine passed over the centers, and might, under extreme conditions, run up the stress far beyond that produced by the steam pressure. Indeed, so general was the belief that the rods might break at any time, that it was customary to protect the engineman in the cab by lining the under side of the running board or floor with heavy iron plates, ⅜ inch or more in thickness, to "armor plate" it, so to speak, to resist the blows which the ends of the broken rod would shower upon it if the accident occurred when the engine was running at a high rate of speed. It was no unusual sight to see engines which were not so protected with one side of the cab badly wrecked from a broken rod. The idea that it was possible to calculate accurately the strains to which a parallel rod was subjected was received at first with incredulity by the older class of railroad mechanical men.

Even with the best form of rectangular section; that is, one deep and thin in the center of, say, 1½ by 6 inches, Fig. 1, the sectional area would be 9 square inches, with a weight of 30.6 pounds per foot, and a section modulus of $\frac{b\,d^2}{6} = 9$. An I-section, 6 inches deep and 2½ inches wide, Fig. 2, would have a sectional area of 6.5 square inches, a weight of 22.1 pounds per foot and a section modulus = 10.73. The advantage then of the I-section is apparent at a glance. Not longer than 10 or 11 years ago* the fact gained wide acceptance that the centrifugal force caused by far the greatest stresses which the rod had to bear. After this the use of I-section rods, which had been slowly coming into use, increased very rapidly, and at the present time nearly all fast running engines requiring long rods, or those over 5 or 6 feet in length, are designed of I-section, having a minimum weight and a high section modulus. Rods of this description, suitably designed and made of good material, rarely break in service. The forces which produce stresses in the rods under discussion are: (a) The push and pull of the piston; (b) Any variation in the length of the rod from that of the distance between centers of the driving axles and the inequality of the crank pin angles; (c) The unequal adhesion of the driving wheels upon the rails, and (d) The centrifugal force, tending to bend the rod transversely in the vertical plane of oscillation. The last, (d), causes, in certain types of engines by far the greatest stresses which the rods have to withstand, producing alternately tension and compression in the outer fibers of the metal, as the rod, supported only at either end, is thrown upward and downward, reversing the stresses for every revolution of the wheel.

Two general divisions of these forces may also be made—the stresses which may and those which cannot be calculated. Those which may be calculated are the thrust of the piston and the centrifugal force, and those which cannot are the non-parallelism of the rods and the unequal adhesion of the driving wheels upon the rails. The stresses caused by the piston are compression and tension acting in line, lengthwise of the rod and parallel, or coinciding, with its axis x x, Fig. 3.

In an eight-wheel engine of the American type half the piston thrust is normally transmitted to the rear wheel through the parallel rod. The fiber stress will $= \frac{D^2 .7854\ P}{2\ A}$, in which:

D = the diameter of the cylinder.
P = the boiler pressure.
A = the sectional area of the rod.

In a mogul and ten-wheel engine the fiber stress will $= \frac{D^2 .7854\ P}{3\ A}$.

And in a consolidation $\frac{D^2 .7854\ P}{4\ A}$.

The centrifugal force gives rise to transverse stresses acting in a vertical plane perpendicular to the longitudinal axis of the rod, in a similar manner to a beam supported at both ends

* Problem of the Locomotive Side Bar, J. B. Johnson, R. R. Gazette, Sept. 16, 1887.

and uniformly loaded along its entire length, as shown in Fig. 3.

It is a well established fact that if the known stresses are properly provided for and a suitable factor of safety introduced, that the increase caused by the unknown will not require much attention in the design. The adjustment, however, should be carefully attended to in service. A few moments reflection will make this clear. The amount of metal required to provide a suitable section to resist the centrifugal force and the tension and compressive stresses will give a sectional area so large, comparatively, that the unknown and non-computable forces, which act directly along its length, divided by this area, will be so small, compared to those acting in a direction perpendicular to its length (whose maximum strain is only on the outer fiber) that its addition will not materially affect the problem. It is also probable that the springing of the crank pins and driving axles will, to a great extent, relieve the strain before the danger line is reached. This is more particularly true when the parallel rod is outside the main rod.

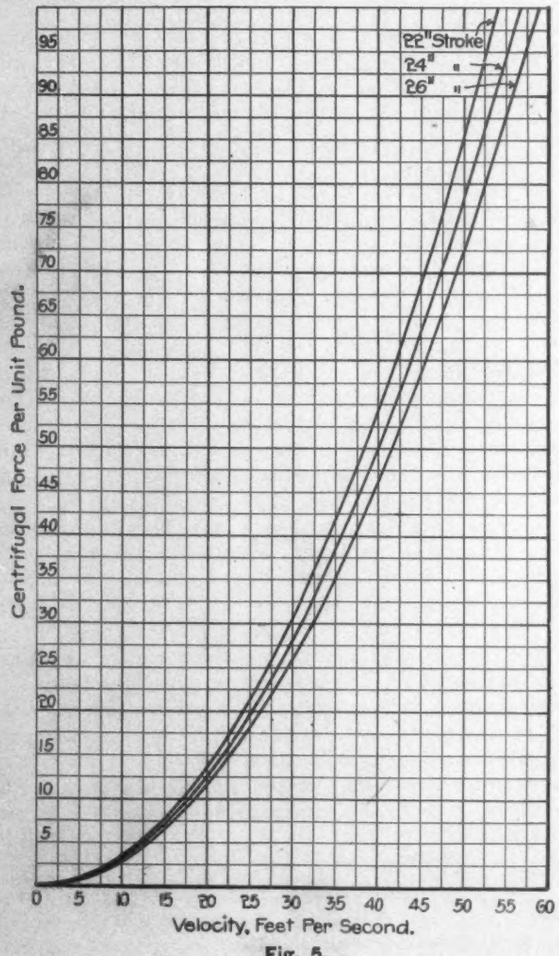


Fig. 5.

For a body moving in a circular path the centrifugal force $F = \frac{W v^2}{r g}$, in which:

W = the revolving weight.

v = the velocity in feet per second.

r = the radius of the circular path in feet.

g = the acceleration of gravity = 32 ft. per second.

For a rod of I section, Fig. 4, the sectional area is 6.56 square inches. The moment of inertia $= \frac{b\,h^3 - 2\,b'\,h'^3}{12}$. The section modulus $= \frac{I}{0.5\,h}$. Substituting the dimensions of the section, $\frac{2.5 \times 5.25^3 - 2 \times .938 \times 3.5^3}{12} = 23.446$ moment of inertia. $\frac{23.446}{0.5 \times 5.25} = 8.931$ section modulus. Length between centers of rod = 100 in. Diameter of driving wheels = 68 in. Revolutions per second, at 80 miles per hour, = 6.59. Radius of crank pin circle = 1 ft. Velocity of crank pin in feet per second = 6.59 × 6.28 = 41.38. Weight of section per foot = 22.33 lbs. Weight of rod (except ends) = 22.33 × 8.33 = 186 lbs. $F = \frac{186 \times 41.38^2}{32} = 9{,}952$ lbs.

The maximum stress in the outer fibres = $S = \frac{WL}{8\,M}$, in which:

W = the weight of force in pounds, uniformly distributed.

L = the length between centers or pins in inches.

M = the section modulus.

Substituting the known values, $S = \frac{9{,}952 \times 100}{8 \times 8.931} = 13{,}929$ lbs. fibre stress per square inch. Eighty miles per hour is doubtless a higher speed, and consequently a greater centrifugal force than is reached in actual service. It is not probable that a speed of 70 miles per hour is often exceeded with this diameter of driving wheel. The dimensions are taken from a class of eight-wheel American type of engines, a number of which have been running in heavy express service for eight or nine years without any breakages of parallel rods.

The maximum stress in the outer fibres for centrifugal force alone at 70 miles per hour is:

Revolutions per second = 5.766.

Velocity in feet per second = 36.21.

$F = \frac{186 \times 36.21^2}{32} = 7620.$

$S = \frac{7620 \times 100}{8 \times 8.931} = 10{,}667$ lbs. fiber stress.

By the use of the diagram Fig. 5, the centrifugal force for each pound of weight of rod at any given velocity may be read off at once. Take the last example, 36.31 ft. velocity per second. Follow up from the bottom on the vertical lines corresponding to 36.31 until it intersects the curved line marked 24-in. stroke; then follow the horizontal line to the left hand side and read off 41. The rod weighs 186 lbs. and 41 × 186 = 7,626 lbs. This gives the centrifugal force within 6 lbs. of that found by calculation.

Table 1 gives the area, weight per foot (steel); moments of inertia, axes, horizontal and perpendicular; least radius of gyration, and the modulus of section for rectangular bars 3 in. to 6 in. deep.

The moment of inertia, axis horizontal, may be obtained for I sections by adding together the proper widths and subtracting the part cut out in the sides. Example, Fig. 4, from the table, twice 1¼ × 5¼ = 2½ in. × 5¼ in. The moment of inertia = 30.14, ⅞ × 3½ in. = 3.12, 1 in. × 3½ = 3.57. Then 30.14 − (3.12 + 3.57) = 23.45 moment of inertia. Since the centrifugal force increases or decreases directly as the weight, the rod may often be reduced in size by thinning down or making a smaller section, preserving the relative strength or what is the same thing, a similar ratio between the section modulus and the weight per foot.

The thrust of the piston, transmitted through the parallel rod, equals the area of the piston multiplied by the maximum steam pressure, divided by the number of driving wheels on one side. For an eight-wheel engine of the American type this equals $\frac{D^2 \times 7854 \times P}{2}$, substituting the dimensions of the en-

gine under consideration; (20 in. cylinders and 165 lbs. steam pressure), the force transmitted through the rod is 25,900 lbs. The stress per square inch in tension will equal

$\frac{F}{A}$, in which:

F = the force transmitted.

A = the cross sectional area of the rod.

Then $\frac{25{,}900}{6.56} = 3{,}948$ lbs. stress per square inch.

Good practice seems to indicate that the normal force transmitted directly through a steel rod, in tension or compression, should not exceed 5,000 lbs. per square inch; that is, the sectional area of the rod should not be less than that proportion of the piston effort which the rod has to convey to the back or front wheels, divided by 5,000. This comparatively low figure may be accounted for when it is remembered that the slipping of one pair of wheels, with sand under the others, may cause the normal force to be increased at least 50 per cent., or considerably more if the crank pins are improperly "quartered."

(To be continued.)

TABLE I.

$$\text{Modulus of section} = \frac{b\,h^2}{6}$$

$$\text{Moment of inertia} = \frac{b\,d^3}{12}$$

$$\text{Least radius of gyration} = \sqrt{\frac{1}{A}} \quad \text{or} \quad \frac{\text{Least side}}{3.46}$$

Size.			Moment of Inertia. Axis Hor.	Axis Per.	Weight per ft. steel.	Least Rad. of G.	Modulus of section Axis Hor
¾	3	2.25	1.68	.1054	7.65	.216	1.12
⅞	3	2.63	1.82	.1675	8.93	.252	1.21
1	3	3.	2.25	.250	10.20	.288	1.50
1⅛	3	3.38	2.53	.356	11.48	.324	1.69
1¼	3	3.75	2.81	.488	12.75	.360	1.87
⅞	3¼	2.84	2.50	.1814	9.67	.252	1.54
1	3¼	3.25	2.86	.2708	11.05	.288	1.76
1⅛	3¼	3.66	3.22	.3854	12.43	.324	1.98
1¼	3¼	4.06	3.57	.5289	13.81	.360	2.20
1⅜	3¼	4.47	3.92	.7039	15.20	.396	2.41
⅞	3½	3.06	3.12	.1954	10.41	.252	1.79
1	3½	3.50	3.57	.291	11.90	.288	2.04
1⅛	3½	3.94	4.02	.415	13.39	.324	2.29
1¼	3½	4.38	4.46	.569	14.87	.360	2.55
1⅜	3½	4.81	4.91	.7589	16.36	.396	2.81
1½	3½	5.25	5.36	.9843	17.85	.433	3.06
1	3¾	3.75	4.39	.3125	12.75	.288	2.34
1⅛	3¾	4.22	4.94	.4446	14.34	.324	2.63
1¼	3¾	4.69	5.49	.6103	15.94	.360	2.93
1⅜	3¾	5.16	6.04	.8122	17.53	.396	3.22
1½	3¾	5.63	6.59	1.055	19.13	.433	3.51
1⅝	3¾	6.09	7.14	1.340	20.72	.469	3.81
1¾	3¾	6.59	7.69	1.674	22.32	.505	4.10
1	4	4.	5.33	.333	13.60	.288	2.67
1⅛	4	4.5	5.99	.474	15.30	.324	2.99
1¼	4	5.	6.66	.651	17.0	.360	3.33
1⅜	4	5.5	7.33	.866	18.70	.396	3.67
1½	4	6.0	8.00	1.125	20.40	.433	4.00
1⅝	4	6.5	8.66	1.430	22.10	.469	4.33
1¾	4	7.0	9.33	1.786	23.80	.505	4.67
1	4¼	5.0	6.39	.354	14.45	.288	3.01
1⅛	4¼	4.78	7.19	.5040	16.26	.324	3.38
1¼	4¼	5.31	8.00	.6917	18.06	.360	3.76
1⅜	4¼	5.84	8.80	.9205	19.87	.396	4.14
1½	4¼	6.38	9.60	1.195	21.68	.433	4.51
1⅝	4¼	6.91	10.40	1.519	23.48	.469	4.89
1¾	4¼	7.44	11.20	1.898	25.29	.505	5.27
1⅞	4¼	7.97	12.00	2.334	27.10	.541	5.64
2	4¼	8.50	12.79	2.833	28.90	.577	6.02
1⅛	4½	5.06	8.54	.5356	17.22	.324	3.79
1¼	4½	5.63	9.49	.7324	19.13	.360	4.22
1⅜	4½	6.19	10.44	.9746	21.04	.396	4.64
1½	4½	6.75	11.39	1.265	22.95	.433	5.06
1⅝	4½	7.31	12.34	1.609	24.87	.469	5.48
1¾	4½	7.88	13.29	2.009	26.78	.505	5.91
1⅞	4½	8.44	14.24	2.471	28.69	.541	6.33
2	4½	9.00	15.18	3.00	30.60	.577	6.75
1⅛	4¾	5.34	10.05	.5633	18.17	.324	4.23
1¼	4¾	5.94	11.16	.7730	20.19	.360	4.70
1⅜	4¾	6.53	12.28	1.023	22.21	.396	5.17
1½	4¾	7.13	13.39	1.336	24.23	.433	5.64
1⅝	4¾	7.72	14.50	1.698	26.25	.469	6.11
1¾	4¾	8.31	15.62	2.121	28.27	.505	6.58
1⅞	4¾	8.91	16.74	2.609	30.28	.541	7.05
2	4¾	9.50	17.86	3.166	32.30	.577	7.52
1¼	5	6.25	13.01	.813	21.25	.360	5.21
1⅜	5	6.88	14.31	1.083	23.38	.396	5.73
1½	5	7.5	15.61	1.406	25.50	.433	6.25
1⅝	5	8.13	16.91	1.787	27.63	.469	6.77
1¾	5	8.75	18.21	2.233	29.75	.505	7.29
1⅞	5	9.38	19.51	2.746	31.87	.541	7.81
2	5	10.00	20.82	3.333	34.00	.577	8.33
1¼	5¼	6.56	15.07	.8544	22.32	.360	5.74
1⅜	5¼	7.22	16.58	1.137	24.54	.396	6.31
1½	5¼	7.88	18.03	1.476	26.78	.433	6.88
1⅝	5¼	8.53	19.54	1.877	29.01	.469	7.45
1¾	5¼	9.19	21.06	2.344	31.24	.505	8.02
1⅞	5¼	9.84	22.58	2.883	33.47	.541	8.59
2	5¼	10.50	24.11	3.500	35.70	.577	9.19
1¼	5½	6.88	17.32	.895	23.38	.360	6.30
1⅜	5½	7.56	19.05	1.191	25.71	.396	6.93
1½	5½	8.25	20.79	1.547	28.05	.433	7.56
1⅝	5½	8.94	22.52	1.966	30.39	.469	8.19
1¾	5½	9.63	24.23	2.456	32.73	.505	8.82
1⅞	5½	10.31	25.98	3.021	35.06	.541	9.45
2	5½	11.0	27.729	3.66	37.40	.577	10.08
1¼	5¾	7.19	19.80	.9358	24.44	.360	6.88
1⅜	5¾	7.91	21.78	1.245	26.88	.396	7.58
1½	5¾	8.63	23.76	1.617	29.33	.433	8.27
1⅝	5¾	9.34	25.74	2.055	31.77	.469	8.95
1¾	5¾	10.06	27.72	2.568	34.22	.505	9.64
1⅞	5¾	10.78	29.70	3.158	36.65	.541	10.33
2	5¾	11.50	31.68	3.833	39.10	.577	11.02
1¼	6	7.5	22.50	.976	25.50	.360	7.50
1⅜	6	8.25	24.75	1.299	28.05	.396	8.25
1½	6	9.0	27.00	1.687	30.60	.433	9.00
1⅝	6	9.75	29.25	2.140	33.15	.469	9.75
1¾	6	10.5	31.50	2.679	35.70	.505	10.50
1⅞	6	11.25	33.75	3.295	38.25	.541	11.25
2	6	12.0	36.00	4.00	40.80	.577	12.00

THE CONSTRUCTION OF A MODERN LOCOMOTIVE*.

By T. R. Browne, Master Mechanic, Juniata Shops, P. R. R.

VII.

General Summary of Tools and Their Arrangement.

There is probably no question in connection with the erection and equipment of a new plant more perplexing or more difficult to decide with any degree of definiteness which will carry with it a satisfying conviction that the conclusions are correct or within a very close limit, than that of the selection and arrangement of tools, and we question whether it is really possible to decide except with a degree of relative accuracy on the amount of equipment which will be required, even where an exact and very detailed knowledge of what it is desired to construct exists. Before even approximate conclusions on a question of this kind can be arrived at, after having decided upon the capacity of the proposed works, it is necessary to know the amount of machine work of various kinds which the various parts of an average size locomotive will require, the general character and kind of tools which shall be used, the character and kind of labor which shall be employed in their operation, and the available space for installing this equipment.

The whole operation of machining parts is practically included in the various processes of milling, drilling, planing, slotting, boring, threading, etc., and, as it has been found convenient to pay for these various operations upon a basis of the lineal inches of thread cut or holes bored, the square inches of milling, planing or slotting, calculations for determining these are made accordingly.

We consider that it is a mistake to overlook the fact that shops for the construction of locomotives are as essentially a special plant for the construction of a special product as any other line of manufacture in which one line of product constitutes the largest amount of output, and that the adoption of special tools and equipment for this line of work is fully as important and will bring proportionately as large returns in profit as the adoption of this character of machinery in other special lines. It is believed that there are very many cases where the standard equipment furnished by manufacturers is adopted for the construction of parts in locomotive work where special tools and special facilities adapted to this peculiar line of work would create a much larger profit than the equipment referred to. It is true that a slight variation in design in many cases will necessitate a change of method, but it is also true that, considering a large variety of designs of locomotives, there is a general sameness existing which would in no way interfere, but rather encourage, the general adoption of more special facilities for this character of work than has been generally the case. It it also true that the general character and design of tools is largely a matter of personal preference either on the part of those who are in direct charge of the plant, or, in many cases,

*For previous article see issue of November, 1898, page 357.

of the foreman in charge of the shop in which this equipment is placed, and, considered from this standpoint, the general character of the supervision, its intelligence and discrimination in favor of the most modern methods, will have an important bearing on the economy of whatever equipment may be adopted.

The great improvements which have been made in modern tools and machinery have, to a very large extent, made unnecessary the employment in the operation of this machinery of what are known as "first-class, all-around mechanics," encouraging the use instead of what may be termed a "specialist" class of operatives, who become skillful in connection with the one machine which they operate. This class of men are frequently those who have had no opportunity to learn a trade, but possess sufficient mechanical ability to adapt themselves to one general condition. The earnings which they can make are largely in excess of what they could realize in any other way, and are generally more than satisfactory, although less than the amount which would be required if the machinery were operated by a skilled mechanic. It has been found advisable to consider the skilled mechanic's usefulness as being confined entirely to that class of work which includes the manufacture of small tools and equipment required in a plant of this kind, and the general maintenance of the large amount of machinery operated by specialists, and the return for the amount paid the skilled mechanic in this kind of work, generally speaking, is very much more than would be the case if he were employed in connection with actual production and operation of the various machines throughout the plant.

In previous articles we have laid special stress on the importance of having all of the operations on various parts required in the completed locomotive carried on in such manner as to be steadily progressive, with a view of obviating any retrograde movement, which would mean lost time and additional expense, and we cannot too strongly emphasize the careful consideration of this question in connection with the arrangement of tools and machinery, or the buildings themselves, in a new plant.

The available amount of ground will in many cases necessitate arrangements which, considered from this standpoint, are not perfectly satisfactory, and we can conceive of conditions in which it would be cheaper to purchase the amount of additional ground required for a better arrangement at even a high figure than to provide an expensive installation which, owing to lack of proper arrangement, is a constant expense which, per year, will be found to represent an interest on an investment very much larger than the additional amount required would have cost.

Careful calculations made to determine the total amount of various kinds of finish required on one locomotive, and, considering a locomotive of the consolidation type of about 90 tons weight, with solid forged frames, finished on top and sides and at such other points where parts are bolted on, and in other respects no more finish than is absolutely essential consistent with safety and general economy of maintenance, develops the amounts of machine work given below. For general convenience, we have divided the kinds of work into five distinct parts: First, all of the work which is done in the machine shop; Second, the amount of machine work which is done in the blacksmith shop; Third, the amount of forging done in the blacksmith shop; Fourth, the amount of machine work on boilers in the boiler shop; and, Fifth, the amount of work done in the brass room.

It will be noted that we have only covered the largest operations in these calculations, considering it advisable to avoid as much detail as possible, the object being to furnish a general suggestion rather than an exact detail, and in this respect have not included the tank work, foundry work or wood work. We have also omitted, and, compared with the total average of other work, this is very small, the pipe work and ordinary sheet iron work, a very large amount of this work being purely labor without an introduction of machines to any very large extent:

Total Amount of Work in Machine Shop.

Planing. Square inches.	Turning. Square inches.	Boring. Square inches.	Milling. Square inches.	Slotting. Square inches.	Cold-sawing. Square inches.	Drilling. Linear inches.	Tapping, Linear inches.
77,089	83,419	9,915	13,995	20,116	595	6,852	612

Total Amount of Work in Bolt Department—Blacksmith Shop.

Turning. Linear inches.	Threading bolts and studs Linear inches.	Threading nuts. Linear inches.
3,363¼	11,421½	2,833½

Total Amount of Forging in Blacksmith Shop.

Total amount of forging in blacksmith shop, including forgings of bolt department	61,819 pounds.

Total Amount of Work in Boiler Shop.

Planing edges of plates. Square inches.	Shearing Square inches.	Punching. Holes.	Tapping. Linear inches.
2,253	2,653	10,915	733

The different divisions of work required in finishing the amount of brass work required for one engine are so small, comparatively, and the large variety of automatic machinery available for this purpose is so large, that we have omitted making any special figures representing the various processes through which this work would go, considering in the light of general information, which it is necessary to have for the larger amount of installation, that this detail would be unnecessary.

Of the various divisions of machine work performed in machine shops 46.3 per cent. of the planing is represented by the work done on frames, cylinders, foot plates, guide yokes, truck plates, frame braces, steam chests, bumper castings and pedestal braces; 64.2 per cent. of the turning is represented by wheel centers, tire, axles, lift shafts, rockers, cylinder heads, pistons and rings, boiler rings, front and extension rings, steam chests, eccentrics and straps; 70 per cent. of the slotting is represented by work required on frames and braces, crossheads, foot plates, bumper castings, guide yokes and driving boxes; 87 per cent. of the milling is represented by guide yokes, crossheads, rods and braces, mud rings, guides, main axles, links and hangers, guide yoke knees; 89 per cent. of the boring is represented by cylinders, crossheads, rocker boxes, lift shaft bearings, lift shafts and rockers; 68.7 per cent. of the drilling is represented by that required for rods, crossheads, holes for pedestal bolts, and cylinders; 65 per cent. of the tapping is represented by that required in connection with cylinders, pistons and the larger parts which are tapped in the machine in which they are drilled.

The difference between the percentages specified, including certain specified kinds of work, and the total of such work includes all of the smaller parts which are capable of being grouped on special machines according to the character of facilities provided; 70 per cent. of the turning on bolts and studs in the bolt department of the blacksmith shop is represented by bolts and studs from 5-16 in. to 1 in., and the balance from 1 in. up; 74 per cent. of the threading is represented by bolts and studs from 5-16 in. to 1 in., and the balance from 1 in. up; 39 per cent. of the tapping required in nuts is represented by nuts from 5-16 in. to 1 in., and the balance from 1 in. up.

The division of the total forging in the blacksmith shop will be about as follows: 58.9 per cent. represents frames, braces, guide yokes, guides, rods, truck plates, pistons, and that class of work which will require hammers of not less than 6,000 to 8,000 lbs. capacity; 20 per cent. represents mud rings, front end extension rings, spring rigging, smoke box braces, piston rods, valve yoke and rods, brake rigging, link and valve motion, crossheads, lift shafts, rockers, and that class of forgings which should not be done on a hammer of less than 3,000 lbs. capacity; 6 per cent. is represented by bolts and forgings of that nature made in the bolt department. The balance includes the smaller classes of forgings, for which, owing to great variety of designs and engines, it is not desirable to construct special

tools or dies, and which are most frequently made over the anvil.

We have implied the use of steam hammers to a large extent in getting out this work, although it is our conviction that a very large amount, if not the entire amount, of the smaller class of forgings, which are comprised under the general headings of crossheads, piston centers, link and valve motion, spring rigging, brake rigging, as well as boiler braces, can be more advantageously made in special dies, and these dies used in a forging press of sufficient capacity. The great advantage of doing the work in this way lies largely in the fact that the dies can be made exceedingly accurate, finely finished, and, owing to the treatment which they receive in the press, will last a long time, the small amount of finish which can be left on this press in many cases making necessary only a process of grinding to complete it. It is a well recognized fact that metal, under a steady pressure, can be caused to assume distorted shapes which any amount of blows in a steam hammer would never produce. It is also true that, even if the attempt were made to use dies for this purpose, in a steam hammer, the life of the dies would be so ridiculously short as to make that kind of a performance an exceedingly extravagant one to perpetuate. A forging machine will almost entirely do away with the necessity of trimming or finishing up work over anvils, as well as greatly reduce the amount of time required to get out the parts required in the blacksmith shop and the time consumed in machining the parts as at present constructed in the machine shop. It is true that in an operation of this kind two sets of dies will be required, one for roughing and the other for finishing, the roughing die roughing the work possibly within ⅛ in. to 3-16 in. of size, and the finishing die completing it to within 1-32 in. of size. A machine of this type will render the installation of a large number of steam hammers unnecessary. These are always more or less extravagant in consumption of steam and expensive to operate, and we believe that the steam consumed by the pump in providing the necessary amount of hydraulic pressure for operating hydraulic machines will amount to considerably less than that consumed by a sufficient number of steam hammers to get out the same amount of work.

The necessity for sub-division of the different kinds of work performed in the boiler shop by machinery does not exist to the same degree as is the case with the machine shop. In the case of planing, a plate planer which will plane 1¼-in. plate will answer for all others of less thickness. A shear which is capable of shearing 1¼-in. plate will likewise shear plate of less thickness. It is also true in connection with punching that a punch which will take care of plate of this thickness and of holes that do not exceed 1¼ in. will answer for lighter work. In the case of tapping, as most of this is comprised in the tapping of staybolt holes, the necessity of sub-division for the purpose of providing tools of different capacity for this work does not exist.

Therefore, in considering the tool equipment for a shop of this kind, the points which would naturally be considered would be the depth of throat of machines for punching and shearing and their power capacity, with reference to the arrangements for doing the work or carrying the work through the shop, the greatest depth of throat generally being required in a machine used for punching holes in flue sheets. This need not in any case be more than from 40 to 45 in. In most cases one double side plate planer capable of taking care of plate up to 1¼ in. will be found more than ample to keep up a reasonable capacity.

Obviously, the number of rivets to be driven will be approximately equal to about one-half the number of holes which are to be punched, and the adaptability of riveters to the work which they have to do is proportionate to the length of reach and size of rivet, the largest sizes including one sufficient for firebox work, and a size sufficient to take in the whole length of the boiler, including the front and extension, it being advisable to drive all the rivets by machinery if possible

In a general sense, all of the tools and equipment can be divided into two classes: That class of tools which in their operation have a reciprocating motion, and spend about one-half of their total time of operation in recovering for the next movement, in which would be included planers, slotters, shapers, steam hammers, bolt machines, punches, shears and riveters, and that class of machinery whose operation is continuous, in which can be included milling machines, drill presses, boring, tapping and threading machinery and lathes. In figuring capacity of tools, an allowance must be made in each of these cases which will represent the lost time of the tool itself, as in the case of planers, representing nearly one-half plus the time required to set and handle the work. Generally speaking, it will be found that about one-half of the time required to turn out a given amount of work is consumed by getting ready, added to the lost time in the machine itself and general handling of parts. Proper facilities in the way of jigs, fixtures, method of handling, as well as a careful adjustment of prices, will go a long way toward reducing this difference, and, with proper supervision of detail, this fact will never be lost sight of, and the greater proportion of time consumed in doing a given amount of work will be that performed by the machine.

We have observed that the output was produced at the lowest possible cost in every case where the time performed by the machine in actually removing material was greater than the time required to prepare the work for this operation.

The adoption of special equipment along similar lines to those adopted by manufacturers of such equipment made in large quantities and on an interchangeable basis will, we believe, in time, almost entirely do away with the necessity for laying off work, and the large amount of rehandling incident to the production of almost every one of the parts of a modern locomotive.

We cannot ignore the fact that the capacity of even the most modern kind of equipment is very largely, if not in some cases entirely, controlled by the operator. His interest is only to get out as much work as he is paid for, and if the adjustment of price is not in the interests of economy or greater output from that particular tool, its output will be represented by exactly what the operator determines it shall be. For this reason the question of deciding as to the number of tools which will be required to do in one day or one month any proportion of the work on one locomotive as we have specified it, becomes a difficult one, and is largely governed by the maximum price per day that it is decided labor shall earn. The personal element, as we choose to term it, in connection with the operation of modern machinery, cannot be eliminated as long as this machinery requires an operator, but we believe that it is a mistake to determine the price to be paid for a given amount of work by the individual skill of the operator who is to do it, and that the capacity of the machine should be considered first, and an operator selected who can get out that capacity.

We have indicated the amount of work of various kinds required for one engine. With any known capacity this will become a multiple of the whole, and the amount of work to be turned out in one day will be proportionate. The number and kind of tools required to turn out this amount of work will be decided by a knowledge of the character and kind of tools available, whose output will be equal to the maximum amount of this with the minimum amount of expense for labor. This will also be governed, to a large extent, by the system of handling and doing the work which it shall be decided to adopt.

The amount of floor space required for a given amount of equipment and for a given amount of work will vary with the character of the work. Obviously, more floor space with a given amount of investment in the tools contained will be required in the boiler shop than would be the case in the machine shop. This would likewise be true in connection with the blacksmith shop.

It is, of course, understood that the investment represented

by each individual tool must earn its proportion of the expense of operating the plant, and that in this expense will be included its own repairs. In addition to this, it must earn on its output its particular proportion of the profit. We know of no fixed rule which can be applied to determine the amount of floor space required for a given amount of equipment. In the case of the machine shop, it will be found that for each machine the floor space required for operator, proper handling of work, etc., at that particular machine, will be very closely equal to twice the area occupied by the machine itself, the dimensions for determining the area occupied by the machine being equal to the product of its two extreme dimensions, and that the amount of floor space required in aisle room and general passageway will be approximately equal to 25 per cent. more than the space occupied by the machine. These figures do not allow for extensions or additional machines, but are intended only to include the original installation, placed as closely together as will be consistent with safety to the operator and handling of material.

In the case of the boiler shop these figures will not hold good to the same extent, owing to the fact that the material handled at machines is frequently from three to four times the area of the space occupied by the machine itself, and it is also true that in this shop fully 75 per cent. of the floor space must be left free for the general handling of material and erecting.

In the blacksmith shop the conditions are in very many respects similar to those in the boiler shops, excepting in the matter of waste floor space. There being no erecting in this shop, the greatest amount of space is required around the tools where work is being done, and we would suggest an allowance of floor space for general handling of material equal to 50 per cent. in excess of the space occupied by the tools and that required for handling the parts in process of manufacture at these tools.

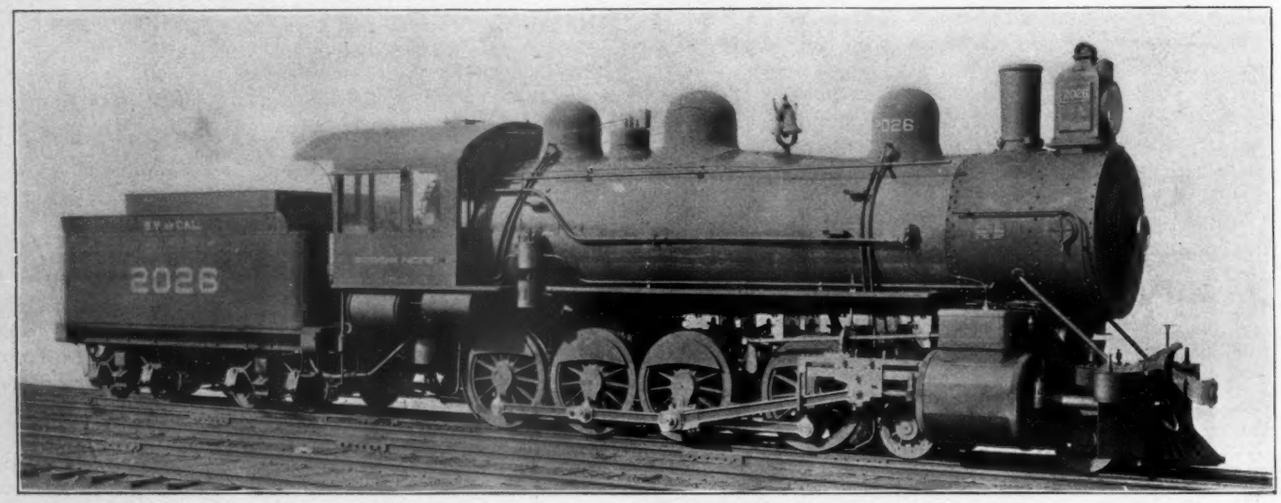
MECHANICAL STOKERS FOR MARINE BOILERS.

The mechanical stoker, in stationary practice, has been brought to a point justifying reference to it as an economical and efficient device. While there appear to be good reasons for experimenting with it in the field of marine engineering, we think that the first application of this kind to be made is that of the "American Stoker" in connection with Babcock & Wilcox boilers on a ship of the Zenith Transit Line, running between Cleveland and Duluth, on the Great Lakes. This form of stoker employs a screw conveyor, driven by a small motor, and the coal that is placed in a hopper at the furnace front is carried into the furnace and to the top of the fire along the length of the furnace. The coal slides down and spreads upon the grates, and as it passes up into the furnace it is heated and, giving off gas, it becomes coke before reaching the grates. The gases are burned as they are given off, and this, the coking and the agitation of the fuel in its delivery combine to give satisfactory combustion. If successful, this experiment may lead to further use of stokers in this service. The conditions which obtain in the fire rooms of ships need the improvement that automatic stokers can give, providing they can do the work without breaking down or requiring too much attention and outlay for repairs.

MASTODON COMPOUND LOCOMOTIVES, SOUTHERN PACIFIC RAILWAY.

The heaviest two-cylinder compound locomotive of which we have record up to this time is the mastodon or 12-wheel type built by the Schenectady Locomotive Works for the Northern Pacific and illustrated in our issue of March, 1897, page 97. The same builders have completed ten of the same type, but larger and more powerful, for the Southern Pacific, one of which is illustrated by the accompanying engraving.

Comparison of the dimensions and weights shows that the Southern Pacific design is 12,000 pounds heavier in weight in working order and 5,000 pounds heavier on drivers. The cylinder power is greater, the cylinders of the Northern Pacific being 23 and 34 by 30 inches and of the Southern Pacific 23 and 35 by 32 inches. The low pressure cylinder is one inch larger and the stroke is two inches longer. These, by the way, are the cylinder proportions of the Baldwin two cylinder consolidation compound of the Norfolk & Western, illustrated in June, 1898, page 181. The heating surface of the Southern Pacific engine is 3025.85 square feet, which is somewhat larger than the other, while the grate area is the same. The following table gives the principal dimensions of the new engine:



Schenectady Mastodon Compound.—Southern Pacific Railway.

General Dimensions.	
Gauge	4 ft. 8½ in.
Fuel	Bituminous coal
Weight in working order	192,000 lbs.
" on drivers	155,000 lbs.
Wheel base, driving	15 ft. 6 in.
" " rigid	15 ft. 6 in.
" " total	26 ft. 5 in.
Cylinders.	
Diameter of cylinders	23 and 35 in.
Stroke of piston	32 in.
Horizontal thickness of piston	5¾ and 4¾ in.
Diameter of piston rod	3¾ in.
Kind of piston packing	Cast iron rings
Size of steam ports	H. P., 20 by 2⅛ in. L. P., 23 by 2⅛ in.
" " exhaust "	H. P., 20 by 3 in. L. P., 23 by 3 in.
" " bridges	1⅜ in.
Valves.	
Lead of slide valves	Allen balanced
Greatest travel of slide valves	6½ in.
Outside lap of slide valves	H. P., 1¼ in. L. P., 1¾ in.
Inside lap of slide valves	Clearance, H. P., ¾ in. L. P., ¼ in.
Wheels, etc.	
Diameter of driving wheels outside of tire	55 in.
Material of driving wheels centers	Cast steel
Driving box material	Main, cast steel. Intermediate, F. & B. steeled cast iron
Diam. and length of driving journals	9 in. dia. on main only 8½ in. dia. by 10 in.
" " " "	main crank pin journals main side, 7 by 5¼ in. 6½ in. dia. by 6 in.
" " " "	side rod crank pin journals
	Inter., 5½ by 5 in. Front and back, 5 in. dia. by 3¾ in.
Engine truck, kind	4-wheel swing bolster
" " journals	6 in. dia. by 10 in.
Diameter of engine truck wheels	28 in.
Kind of engine truck wheels	Krupp, cast iron spoke center
Boiler.	
Style	Extended wagon top

Outside diameter of first ring	72 in.
Working pressure	200 lbs.
Material of barrel and outside of fire box	Carnegie steel
Thickness of plates in barrel and outside of fire box	11-16, 13-16, ½, 9-16 and ¾ in.
Fire box, length	120 3-16 in.
" " width	42 in.
" " depth	F., 77 in. B., 73½ in.
" " material	Carnegie steel
" " plates, thickness.	Sides, 5-16 in.; back, 5 16 in.; crown, ⅜ in.; tube sheet, ½ in.
" " water space	Front, 4½ in.; sides, 3½ by 4 in.; back, 3½ by 4½ in.
" " crown staying	Radial stays 1⅛ in. diam.
" " stay bolts	1 in. diam.
Tubes, number of	332
" diameter	2¼ in.
" length over tube sheets	14 ft. 6 in.
Fire brick, supported on	Studs
Heating surface, tubes	2819.34 sq. ft.
" " fire box	206.51 sq. ft.
" " total	3025.85 sq. ft.
Grate surface	35.0 sq. ft.
Ash pan style	Hopper, dampers front and back
Exhaust pipes	Single
" nozzles	5¼, 5½, 5¾ in. dia.
Smoke stack, inside diameter	16 in. near bottom, at top 18 in.
" " top above rail	14 ft. 11 in.
Boiler supplied by	Two injectors—Ohio No. 10 and Monitor No. 10

Tender.

Weight, empty	39,650 lbs.
Wheels, diameter	33 in.
Journals, diameter and length	5 in. dia. by 9 in.
Wheel base	15 ft. ¼ in.
Tender frame	Channel iron
Water capacity	4,500 gals.
Coal capacity	10 tons
Total wheel base of engine and tender	53 ft. 6½ in.

Engine equipped with Westinghouse-American brake on all drivers operated by air; Westinghouse air brake on tender and for train, 9½-in. air pump. Franklin Monarch magnesia sectional lagging. Sweeney brake arrangement on low pressure cylinder. Le Chatlier water brake on low pressure cylinder.

FEED WATER HEATERS FOR LOCOMOTIVES.

True economy in the operation of locomotives lies, to a certain extent, in economical use of fuel, but it is much more important that the maximum number of tons should be hauled over the road at the proper speed and this means that great power is a primary requisite. The limit of power of the locomotive lies in the boiler, and the most desirable improvements it was the practice, for about 25 years, to wash out the boilers at each end of a run of 137 miles or the engines could not make a return trip. The flues would not last over a year and much trouble was had with leaky fireboxes. The use of a simple feed water heater made it possible to run one of these engines five months, making a mileage of 20,000 without washing and without foaming, liberal use being made of blow off cocks. Feed water heaters are in general use in stationary practice where their value as purifiers is recognized, and it is generally accepted that scale 1-16-inch thick means about 12 per cent. additional fuel. Besides this, boilers would be relieved of many destructive strains if fed with hot water, this would probably show in the life of stay bolts and fireboxes.

Simple calculations show the theoretical gains to be expected from heating the feed from 50 degrees F. to 200 degrees for a boiler pressure of 200 lbs. per square inch, to be between 12 and 13 per cent. From data taken in a large number of tests on fuel economizers in England and on the Continent of Europe it has been shown that a saving of from 1.2 to 1.4 per cent. may be expected for each 10 degrees that the feed water is heated. Tests showing as much as 22 per cent. gain have been reported, but only half of this is enough to warrant earnest efforts in investigating this subject. We believe that from 7 to 10 per cent. may be counted upon with safety.

The theoretical gain in per cent is:

$$\frac{100\ (Q-q)}{H-q}$$

Where H=total heat in one pound of steam at boiler pressure, reckoned from freezing.

Q=heat of the liquid at final temperature of feed.

q=heat of the liquid at initial temperature of the feed.

It is interesting to observe that the results of practice are generally better than the theoretical calculations promise, which tends to show that investigation in this field has not been exhausted. Feed water heaters have been decried on account of the comparatively small number of heat units that they put into the water, but it is important to note that the heat units furnished in this way are most valuable ones. The gain appears in three ways: As heat recovered that would otherwise have gone to waste, in increased evaporation per pound of fuel on account of a decrease in the rate of combustion per square foot of grate area and in better circulation in

TEST OF FEED WATER HEATER, WABASH RY.

From	To	Distance.	Total time on road.	Actual running time.	Average speed in miles per hour	Weight of train in tons.	Car mileage.	Ton mileage.	Pounds coal used.	Pounds coal used per car mile.	Pounds coal used per ton mile.	Gallons water used.	Gallons water evaporated per pound of coal.	Miles run per ton of coal.	Average temperature of water in tank.	Average boiler pressure.
Decatur	Brooklyn, L-Y. with	110	4-54	4-12	26.19	691	3,300	76,010	10,000	3 03	.131	6,468	.647	22	107	159
"	" without.	108.4	4-45	4-07	26.33	628.6	2,728.4	68,141.2	11,000	4.031	.161	6,461.4	.587	19.7	51	155
Brooklyn	Decatur, with	108.4	6-05	3-11	34.05	689.2	3,023.3	74,712.7	14,000	4.63	.187	8,019	.572	15.48	108	.....
"	without	108.4	5-24	3-48	28.52	634.9	2,863.2	74,242.4	13,000	4.54	.175	6,271	.482	16 67	51	155
Decatur	Brooklyn, with	108.4	6-20	4-51	22.35	677.12	2,955.3	73,403.6	13,000	4.39	.177	6,875	.528	16.67	103	.....
"	" L-Y, without....	110	5- 2	4-03	27.16	616	3,080	67,760	13,000	4.22	.192	6 943	.534	16.92	52	152
Brooklyn, L-Y.	Decatur, with	110	5-58	4-58	22.14	726	3 300	79,850	11,000	3.33	.137	7,194	.654	20	110	159
"	" without.	108 4	5-55	4-53	22.19	793.2	2,907	85,988.4	15,000	5.159	.174	8,936	.595	14.45	51	148
Decatur.	Brooklyn, with	108.4	5-36	3-43	29.16	801.7	3,484.7	86,904.5	13,000	3.73	.149	7,150	.55	16.67	100	.....
"	" without.	108.4	5-32	4-50	22.42	767	3,252	83,142.8	13,000	3.997	.156	6,270	.482	16.67	61	156
Total, with		..	28 53	20 55	.....	3,585	16,063.3	390,890.8	61,000	....	.....	35,706	....	.....	.....	.....
Total, without		...	26 48	21 41	..	3,489.7	14 830.6	379,274.8	65,000	.....	.....	34,881	.....	.....	.....	.....
Average, with		.....	5 46	4 11	26.06	717	3,212.6	78,178.1	12,200	3.797	.1565	7,141	.5853	17.87	105.6	.....
Average, without		.....	5 22	4 20	25.07	698	2,966.1	75,854.9	13,000	4.382	.1713	6,976	.5366	16.75	53 2	.....
Per cent., with		.	.....	.....	.....	.....	....	.....	.....	13.35	8.64	.....	8.32	6.68	.....	.....

are those that permit of increasing capacity without exceeding the limits of weight. The true function of a boiler is the one pertaining solely to the evaporation of water and making steam. If the other duties ordinarily performed by the boiler can be executed satisfactorily in another way the increase of boiler capacity is promising.

Besides evaporating water at an enormous rate locomotive boilers are called upon to separate the feed water from scale and to furnish a large amount of heat to raise the temperature of the feed water to the point of evaporation. A feed water heater that is not more trouble than it is worth would evidently offer greatly needed relief, because water may be both purified and heated in a heater.

Records of the Union Pacific Railway show that before the application of feed water heaters on one of the worst divisions the boiler, that is to say the heating surface is more efficient when it has to furnish the "latent heat" only. This last mentioned advantage is now attracting a great deal of attention in England, where feed water heating by live steam is reported upon the best of authority as giving as much as 15 per cent. increased economy. When Professor Unwin advocates such practice (as he does) there must be something in it in spite of the fact that it appears to be a case of "Robbe Peter and pay Paule." In Halpin's system of heat storage the boilers are fed with steam heated water and are said in consequence to be enabled to produce one-third more steam than if working direct from the mains. This means more power per pound weight of boiler, which is what we are seeking. There is evidently more to this subject than most people think.

In our issue of April, 1897, page 142, an illustrated descrip-

tion of the Barnes feed water heater was printed. This and the Rushforth heater are probably the best known in connection with locomotives, although others have been successfully tried. On some roads it has for a long time been customary to provide means for blowing back the exhaust of the air brake pump, and years ago attachments were made to the pop valves whereby the escaping steam was carried into the water of the tender tank. These, with Strong's heater, applied to engines on the Chicago & Alton Railroad several years ago, and those applied by Mr. E. M. Herr on the Northern Pacific, which are referred to elsewhere, constitute the most important work that has been done in this direction, but more is likely to be done in the near future.

The heater which uses the exhaust steam from the air brake pump to warm the whole of the feed water in the tender tank is undoubtedly the simplest and easiest to apply and to use. It has been objected to on account of blistering the tank varnish, but other finish may be used; the only valid criticisms on this plan are that there is loss of heat through the large surface of the tank, and owing to the variable amount of water the temperature also will vary considerably. The tank may be lagged, if it is found to be worth while to do so, and as long as the temperature is below the point at which injectors refuse to work the variable temperature does not appear to be troublesome. Mr. J. B. Barnes, Superintendent of Motive Power and Machinery, inventor of the tank heater referred to, has kindly furnished a report from which the accompanying table was prepared, showing the results obtained by using the heater on five trips on engine No. 480 of that road in April, 1897. Five trips were made with the heater in use and five without it, the percentages of saving being indicated in the table.

Closed heaters have been tried in the smoke box and also on the tender, but there appears to be good reason to prefer heating by steam to relying upon the hot gases of the smoke box.

If a closed heater can be made small enough to be carried conveniently on the engine or tender without adding to the troubles of the enginemen and yet large enough to efficiently heat the water, it will undoubtedly pay to try it in service to heat the water to or near the boiling point and force it into the boiler by a steam pump. The exhaust of the air brake and feed pumps and possibly a small portion of the main exhaust of the engine could also be utilized for heating purposes. The heater should be also a water purifier and should be arranged to be easily cleaned from the sediment that now becomes scale and bakes on to the boiler heating surfaces. It would not adhere so closely to the heater surfaces and would wash off. It should be cheap to build and to maintain. The heater must be accessible, and it must be arranged so as to be instantly cut out of the circuit if it fails in any way, and must not then interfere with the ordinary method of handling the feed water. These conditions are severe, but if they can be met we believe that feed water heaters will come into general use. They are worthy of more attention than they have ever received at the hands of locomotive people.

A feed water heater adds something to the equipment of the locomotive, it weighs something of itself and it may require a little attention but the compensating advantages are: Increased boiler power per pound weight, a saving in the amount of coal and water to be carried, a saving of work for the fire to do and consequently there is less wasteful forcing of the fire. The best of these points is the increase in the power of the locomotive. Exhaust steam from the air pump, of which there is about one-tenth of a pound per stroke, may be used and even live steam may be taken for this purpose, with the promise of equally good results as are found in stationary practice.

Some troubles have been experienced in feeding hot water with injectors, but these have been overcome up to temperatures of about 125 degrees. Mr. E. M. Herr recently made a statement in speaking about his form of tank heater before the Western Railway Club, which will be found on another page of this issue.

If on reading these paragraphs some one is led to suggest a study of the application of feed heaters to locomotives the object for which they were written will be attained.

PNEUMATIC HAMMERS FOR RIVETING.

On page 406 of our December, 1898, issue, we stated that the pneumatic tools used by the Chicago Ship Building Company and described in Mr. Babcock's interesting paper on pneumatic riveting in ship building were furnished by the Chicago Pneumatic Tool Company. Information has since been received showing that at the end of September, 1898, which was probably about the date that the paper was written, 17 hammers, now known as the "Q. & C.," and controlled by the Q. & C. Company, were in use by that firm. This shows that our previous statement was an error.

HEAVIER LOCOMOTIVES FOR THE LAKE SHORE.

The policy of the Lake Shore & Michigan Southern of spending a great deal of money in securing favorable grades and using light locomotives is of long standing, but a distinct departure is now made in an order for 45 locomotives that, compared with all except the monsters recently built for special service, must be considered heavy ones. This order was placed with the Brooks Locomotive Works, of Dunkirk, N. Y., and we give some of the particulars of the design in the following table, which indicate the divisions into 15 six-wheel switchers. 15 consolidation and 15 ten-wheel engines:

	Switchers.	Consolidation.	Ten Wheel.
Weight on drivers	128,000 lbs.	133,000 lbs.	118,000 lbs.
Total weight	128,000 lbs.	150,000 lbs.	150,000 lbs.
Cylinders	19 by 26 in.	20½ by 28 in.	19½ by 30 in.
Drivers, outside	52 in.	56 in.	62 in.
Boiler, type	Straight.	Wagon top.	Wagon top.
Pressure	170 lbs.	180 lbs.	180 lbs.
Firebox	34½ by 80 in.	42 by 114 in.	42 by 114 in.
Tank capacity	3,500 gals.	5,000 gals.	5,000 gals.
Coal	5 tons.	8 tons.	8 tons.

The three types will have Westinghouse air brakes, steel axles, Heginbottom bell ringers, National hollow brake beams, Sargent brake shoes, Gould couplers, Monitor injectors, Leach's sanding device, Nathan lubriactors, A. French Co.'s springs, Latrobe tires and cast steel driving wheel centers.

NEW YORK RAILROAD CLUB.

Mr. Angus Sinclair read a paper before this club at the December meeting, in which he briefly sketched the transition from the primitive methods of transportation in European countries to present practice, and compared current European practice with that in this country. The methods of smokeless combustion of coals in Great Britain formed an important factor that was worthy of being copied here. The practice of using cars that were a development of the omnibus, while inferior to American cars in many ways, was explained on a score of lightness. The author commended the treatment of employees on the Continent, which, while strict in discipline, allowed holidays without loss of pay, and also there was considerable freedom with regard to passes for the men and their families.

EDITORIAL ROOMS OF "LOCOMOTIVE ENGINEERING" DESTROYED BY FIRE.

The havoc wrought by a fire which destroys even a part of the papers and records of a periodical publication is not appreciated by those who have not experienced it, and our sympathies are extended to "Locomotive Engineering" for the irreparable loss by the burning out of the editorial rooms and everything in them. The energy of Mr. Sinclair and his associates, who now occupy offices at 95 Liberty street, New York, will doubtless be equal to the emergency, and the January issue will appear as if nothing unusual had occurred. We join in expressing appreciation of the difficulties and praise of the performance.

PERSONALS.

Mr. J. R. Grover has been appointed Master Mechanic of the Kansas City, Pittsburg & Gulf, with headquarters at Wichita, Kan., to succeed Mr. C. A. De Haven, promoted.

Mr. George L. Bradley, the present Vice-President and General Manager of the Lake Erie & Western Railroad, will, it is reported, succeed to the Presidency of that road, made vacant by the death of Calvin S. Brice.

Mr. Oscar Autz has been promoted from the position of General Foreman of the Lake Shore car department at Cleveland and has been succeeded by Mr. W. Snodgrass. Mr. Autz has been with the road about five years, having formerly been connected with the Pennsylvania. He has been a regular contributor to this journal and is an authority on car subjects.

PERSONALS.

Mr. Grinnell Burt has again been elected President of the Lehigh & Hudson. This is his 40th term.

Mr. W. R. McKeen, Jr., has been appointed Master Mechanic of the Union Pacific at North Platte, Neb.

Mr. W. B. Bates has been appointed Master Mechanic of the St. Louis, Iron Mountain & Southern, at Memphis, Tenn.

Mr. James Gray has been appointed Foreman of the shops of the St. Louis, Iron Mountain & Southern at Mer Rouge, La.

Mr. C. A. Coffee has been appointed Master Mechanic and Car Builder of the Oconee & Western, to succeed Mr. A. J. Mentor.

George F. Gardner, formerly Master Mechanic of the Columbus, Sandusky & Hocking, died Dec. 9 at Eldorado Springs, Mo., at the age of 58 years.

Mr. E. D. Jameson has been appointed Assistant Master Mechanic of the Western Division of the Grand Trunk, with office at Battle Creek, Mich.

Mr. W. H. Patton has been appointed Signal Engineer of the Grand Trunk, with headquarters at Toronto, Ont., to succeed Mr. P. F. Hodgson, resigned.

Mr. L. L. Dawson, Master Mechanic of the Illinois Central at Memphis, Tenn., has been transferred to McComb City, Miss., to succeed W. B. Baldwin, deceased.

Mr. William Murdock has been appointed Assistant Engineer of Maintenance of Way of the Toledo Division of the Pennsylvania Company, with headquarters at Toledo, O.

Mr. Edward H. Lee has been appointed Engineer and General Roadmaster for the Chicago & Western Indiana and the Belt Railway of Chicago, vice F. C. Doran, deceased.

Mr. F. M. Gilbert has been appointed Engineer of Tests of the Northern Pacific, with headquarters at St. Paul, Minn. He will also have charge of the electrical work of the road.

William T. Moore, formerly for many years Master Mechanic of the Pittsburg Division of the Pennsylvania Railroad, died at his home in Sewickley, Pa., Dec. 1, at the age of 74 years.

Mr. James H. Manning, the energetic and efficient Master Mechanic of the Union Pacific, at Omaha, has been transferred to Cheyenne, and will have entire charge of the shops there.

Mr. C. L. Mayne, General Superintendent of the Fitchburg Railroad, has resigned. He has been connected with this road for six years and was formerly Superintendent of the Chicago & Atlantic.

Mr. N. E. Clucas, who for several years has been foreman of the Atchison, Topeka & Santa Fe, at Pueblo, Colo., has been appointed master mechanic at La Junta, Colo., to succeed Mr. John Forster.

Mr. D. H. Nichols, Superintendent of the Pecos Valley & Northeastern, has been appointed General Manager to succeed Mr. E. O. Faulkner, resigned. His headquarters are at Eddy, New Mexico.

Mr. O. O. Winter, who for the past year has been Trainmaster of the Norfolk & Western, has been appointed General Manager of the Brainerd & Northern Minnesota, with headquarters at Brainerd, Minn.

Mr. E. Richards has resigned as trainmaster of the St. Louis Southwestern, at Pine Bluff, Ark., to accept the position of General Manager of the Louisiana & Arkansas, with headquarters at Stamps, Ark.

Mr. S. D. Hutchins, who has had charge of the instruction car of the Westinghouse Air Brake Company, has been appointed to succeed the late J. W. Shannon as representative of the company at Buffalo, N. Y.

Mr. J. T. Stafford, heretofore General Foreman of locomotive repairs of the St. Louis, Iron Mountain & Southern, at Baring Cross, Ark., has been appointed Assistant Master Mechanic, with headquarters at the same place.

Mr. Walter G. Berg has been appointed Engineer of Maintenance of Way of the Lehigh Valley, with office at South Bethlehem. He was formerly Assistant Engineer at Jersey City, and succeeds Mr. Richard Caffrey.

Mr. P. J. Harrigan, General Foreman of the Baltimore & Ohio shops at Connellsville, Pa., has been appointed Master Ohio shops of the middle division of that road, with headquarters at Cumberland, Md., to succeed Mr. D. C. Courtney, resigned.

Mr. H. Tandy has resigned as Assistant Superintendent of the Brooks Locomotive Works to become Superintendent of the Canadian Locomotive Works at Kingston, Ontario. Mr. Tandy's experience qualifies him to fill his new position admirably.

Mr. J. C. Gleason has been appointed Superintendent of the Cincinnati, Portsmouth & Virginia, and the heads of the mechanical and road departments are to report to him. He was formerly Superintendent of Transportation, a position that has been abolished.

Mr. C. J. Smith has resigned as General Manager of the Pacific Coast Company, operating the Columbia & Puget Sound, Pacific Coast, Seattle & Northern and Port Townsend Southern Railroads and the Pacific Coast Steamship Company. He has been General Manager of the Pacific Coast Company since 1890.

Mr. A. L. Whipple, railroad representative of the Boston Woven Hose and Rubber Company, has resigned to accept the position of Sales Agent for the E. T. Burrowes Company of Portland, Me. Mr. Whipple is widely and very favorably known among prominent railroad men, and the Burrowes Company has done well to secure his services.

Mr. E. E. Loomis, Superintendent of the Tioga division of the Erie Railroad, has been appointed General Superintendent of the New York, Susquehanna & Western and Wilkesbarre & Eastern, to succeed Mr. C. D. McKelvey, resigned. Mr. Loomis has been with the Erie since April, 1884, and has been Superintendent of the Tioga division since November, 1894.

John E. Wootten, the inventor of the firebox that bears his name, died in Philadelphia December 16, after a brief illness, at the age of 76 years. He was a native of Philadelphia and began railroad work as Mechanical Engineer of the Philadelphia & Reading in 1845. He was rapidly promoted and became General Manager, a position which he held until his retirement from railroad service in 1886.

Calvin S. Brice, ex-Senator and railroad financier, died at his home in New York Dec. 15. At the time of his death he was President of the Lake Erie & Western, President of the Cleveland, Akron & Columbus, and First Vice-President of the Duluth, South Shore & Atlantic. He was born in 1845 and began railroad work in 1870, and his earlier positions were in charge of the legal departments of several roads successively. Mr. Brice's last and largest plan was to build a railroad system in China.

J. Taylor Gause, President of the ship and car building firm, the Harlan & Hollingsworth Company of Wilmington, Delaware, died at his home in that city December 1. He was born in 1823, in Pennsylvania, and begun as an office boy in these works. He advanced steadily, until he became President in 1883. He held that position until his retirement, in 1896, and resumed the office after the resignation of Mr. Henry G. Morse a few months ago. He began his career as a shipbuilder about twenty-five years before the era of iron ships.

Mr. Willard A. Smith, President of the "Railway and Engineering Review," who was Chief of the Transportation Department of the Columbian Exposition in 1893, has been appointed by the United States government to take charge of the Department of Transportation and Civil Engineering of the American Exhibits of the Paris Exposition. His efficient organization of the transportation exhibits at Chicago will be remembered as an important part of the success of that exposition, and a more satisfactory appointment in connection with the Paris exposition could not be made.

R. B. F. Peirce, General Manager of the Indiana, Decatur & Western, and until recently receiver of the Toledo, St. Louis & Kansas City, died suddenly at his home in Indianapolis, Ind., Dec. 5, of heart disease. His health had been poor for months, and he was preparing to enjoy a much-needed rest in California. Mr. Peirce was born in 1843 and was admitted to the bar in 1867. He began railroad service as General Counsel of the Logansport, Crawfordsville & Southwestern in 1873, and has been connected wtih several roads in important positions since that time. In 1895 he succeeded Mr. S. R. Callaway as Receiver of the Toledo, St. Louis & Kansas City Railway.

OUR DIRECTORY

OF OFFICIAL CHANGES IN DECEMBER.

Atchison, Topeka & Santa Fe.—Mr. N. E. Ciucas has been appointed Master Mechanic at La Junta, Colo., to succeed Mr. John Forster.

Baltimore & Ohio.—Mr. P. J. Harrigan has been appointed Master Mechanic of the middle division of this road, with headquarters at Cumberland, Md., in place of Mr. D. C. Courtney, resigned.

Chicago Great Western.—Mr. C. E. Slayton, recently appointed Division Master Mechanic, has had his jurisdiction extended to cover the Eastern Division from Oelwein to Chicago.

Cumberland & Pennsylvania.—Mr. L. M. Hamilton's title of General Superintendent has been changed to that of General Manager, and the title of Mr. H. T. Bruck, Master of Machinery, has been changed to that of Superintendent of Motive Power.

Dayton & Union.—Mr. Charles Treble, Roundhouse Foreman of the Cleveland, Cincinnati, Chicago & St. Louis at Wabash, Ind., has been appointed Superintendent of the Locomotive and Car Department, with headquarters at Dayton, O.

Fitchburg.—Mr. F. O. Melcher has been appointed Superintendent, with office at Boston, Mass., and Mr. A. S. Cheever has been appointed Chief Engineer, with office at Fitchburg, Mass., in place of Mr. Melcher.

Fitchburg.—Mr. C. L. Mayne, General Superintendent, has tendered his resignation, to take effect Jan. 1, 1899.

Genesee & Wyoming Valley.—Mr. D. Hyman has been appointed Receiver, with headquarters at Retsof, N. Y.

Georgia & Alabama.—Mr. C. P. Hammond has resigned as Chief Engineer of this road.

Georgia Pine.—Mr. R. G. Stone has been appointed General Manager, vice Mr. R. B. Coleman.

Grand Trunk.—Mr. E. D. Jameson has been appointed Assistant Master Mechanic of the Western Division, with office at Battle Creek, Mich.

Great Northern.—Mr. R. H. Bowron, heretofore Division Superintendent at Willmar, Minn., has been appointed Superintendent of the Cascade Division, with headquarters at Everett, Wash. Frank Shesgreen, heretofore Division Superintendent at Everett, Wash., has been appointed Superintendent of the Willmar Division, with headquarters at Willmar, Minn.

Illinois Central.—Mr. L. L. Dawson, Master Mechanic, has been transferred to McComb City, Miss., to succeed Mr. W. B. Baldwin, deceased.

Kansas City, Pittsburg & Gulf.—Mr. J. R. Groves has been appointed Master Mechanic of the Kansas Midland Division, with headquarters at Wichita, Kan. He succeeds Mr. C. A. DeHaven, promoted.

Lake Shore & Michigan Southern.—Mr. J. R. Reniff has resigned as Master Car Builder at Norwalk, O., and the position has been abolished. Mr. Oscar Antz has been promoted and Mr. W. Snodgrass succeeds him as General Foreman of the shops at Cleveland.

Lehigh Valley.—Mr. Charles E. Webster, Chief Engineer, has resigned, to take effect Jan. 1, 1899. Mr. Walter G. Berg has been transferred to South Bethelem and promoted to succeed Richard Caffrey as Engineer of Maintenance of Way.

Louisiana & Arkansas.—Mr. Elmer Richards has been appointed General Manager, with headquarters at Stamps, Ark. He was formerly Trainmaster of the St. Louis Southwestern.

Louisville & Nashville.—Mr. Wm. Robb, Master Mechanic at Decatur, Ala., is dead.

Lowell & Hastings.—Mr. C. A. Gordon has been appointed Chief Engineer, with headquarters at Grand Rapids, Mich.

Manitoba & Northwestern Ry. of Canada.—Mr. E. B. Osler has been elected President, with office at Toronto, Ont., and Wm. Hendrie, Vice-President, with office at Hamilton, Ont.

New York, Susquehanna & Western.—Mr. E. E. Loomis has been appointed General Superintendent, to succeed Mr. C. D. McKelvey, resigned. Mr. Loomis was formerly Superintendent of the Erie.

Northern Pacific.—Mr. F. M. Gilbert has been appointed Engineer of Tests, with headquarters at St. Paul, Minn.

Oconee & Western.—Mr. C. A. Coffee has been appointed Master Mechanic and Car Builder, vice A. J. Mentor.

Pacific Coast.—Mr. C. J. Smith has resigned as General Manager of this company, operating the Columbia & Puget Sound, Pacific Coast, Seattle & Northern and Port Townsend Southern.

Pecos Valley & Northeastern.—Mr. D. H. Nichols has been appointed General Manager. He was formerly Superintendent of this road. His headquarters are at Eddy, N. M.

Pennsylvania.—Mr. Wm. Murdock has been appointed Assistant Engineer Maintenance of Way of the Toledo Division, with headquarters in Toledo, O.

Richmond & Petersburg.—At the annual meeting of the stockholders, held in Richmond, Va., November 21, Mr. Alexander Hamilton was elected President, succeeding the late Frederick R. Scott.

St. Louis, Iron Mountain & Southern.—Mr. J. T. Stafford has been appointed Assistant Master Mechanic, with headquarters at Baring Cross, Ark. He was formerly General Foreman of Locomotive Repairs. Mr. W. B. Bates has been appointed Master Mechanic at Memphis, Tenn.

Southern.—Mr. A. E. Bouldridge has been appointed Master Mechanic at Louisville, Ky., succeeding Mr. J. B. Gannon. Mr. Bouldridge was heretofore General Foreman of the Mechanical Department at Atlanta.

Southern California.—Mr. W. G. Nevins, General Manager at Los Angeles, Cal., will have his authority extended over the San Francisco & San Joaquin Valley line, which was recently purchased by the Atchison, Topeka & Santa Fe. His headquarters will remain at Los Angeles.

Stuttgart & Arkansas River.—Mr. A. V. Stafford has been appointed Manager for the Receiver, with headquarters at Stuttgart, Ark., vice Mr. J. B. Hackley, deceased.

Toledo, St. Louis & Kansas City.—Mr. Samuel Hunt has been appointed Receiver, succeeding Mr. B. F. Pierce, resigned, on account of ill health.

Union Pacific.—Mr. J. H. Manning, Master Mechanic at Omaha, Neb., has been transferred to Cheyenne, succeeding Mr. T. A. Davies, transferred. Mr. M. K. Barnum, of North Platte, Neb., succeeds Mr. Manning at Omaha, Neb. Mr. Davies will have charge of the Mechanical Department at Ogden, Utah. Mr. W. R. McKeen, Jr., has been appointed Master Mechanic at North Platte.

Wabash.—Mr. Geo. W. Mudd has been appointed Master Mechanic at Moberly, Mo. He was formerly Master Mechanic at Springfield, Ill. Mr. Geo. S. McKee has been transferred to Fort Wayne, Ind., to succeed Mr. C. H. Doebler, who is made Master Mechanic at Springfield.

THE WHITELAW REVERSIBLE AIR DRILL, BY THE CHICAGO PNEUMATIC TOOL CO.

This drill has recently been perfected and is making an important place for itself in shop equipment. The machine is in the form of a light motor and is adapted to many kinds of work requiring rotary motion, and especially for drilling.

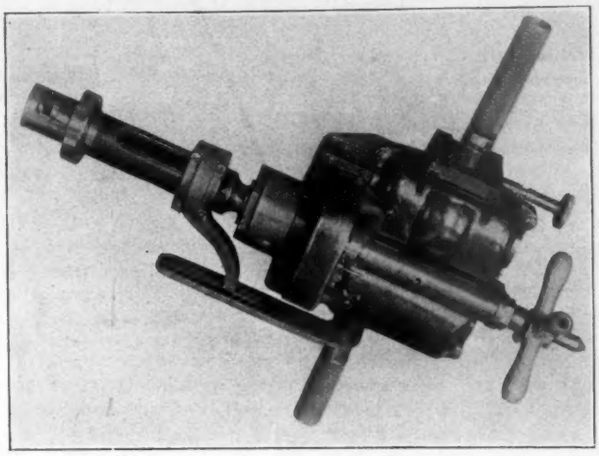


Fig. 1.

It is being introduced by the Chicago Pneumatic Tool Company in two sizes. Fig. 1 shows the No. 7 machine with a newly improved flue cutter atttached, and Fig. 2 shows a No. 8 machine arranged for drilling. Both of the machines are reversible, and are regulated and governed by a throttle operated by a handle that is conveniently located. They have back gears and two speeds, and are surprisingly powerful considering their weight and compact size. The No. 7 drill complete weighs but 19 pounds and the No. 8 weighs 30 pounds.

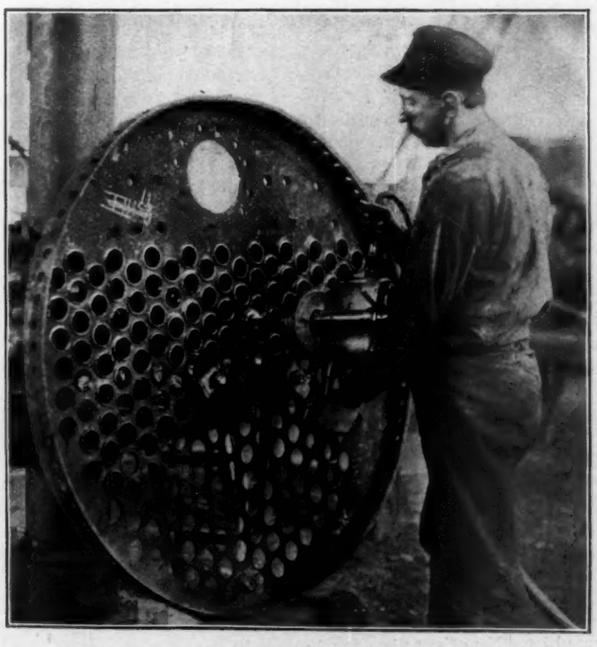


Fig. 13.

The former is specially adapted to locomotive work, and the latter is exceedingly powerful and is intended for heavy boiler and shipyard work. It will drill holes as large as 2 inches in diameter in iron or steel, it will also roll flues that are 4 inches in diameter, and is especially well adapted for heavy tapping where a reversible motor is needed. The machines are fitted with screw feeding attachments for drilling, which are replaced by breast plates when used in rolling flues. The throttle reversing and change gear devices are so arranged as to be very easily manipulated by the operator, and the whole plan of the machine is such as to permit of a large saving of time, labor and expense. It embodies the principle of "taking the machine to the work" instead of taking the work to the machine, and through the large amount of power provided the principle may be carried out to an extent not before attempted.

The machines will find their most extensive use in drilling and in rolling and cutting flues. In some experiments recently carried out at the "Nickel Plate" shops in Chicago it was demonstrated that with a No. 7 machine the cost of cutting out old flues and rolling in new ones may be reduced to 8 1-10 cents each, and when it is considered that a single boiler has from 200 to 350 flues it is clear that a large saving may be

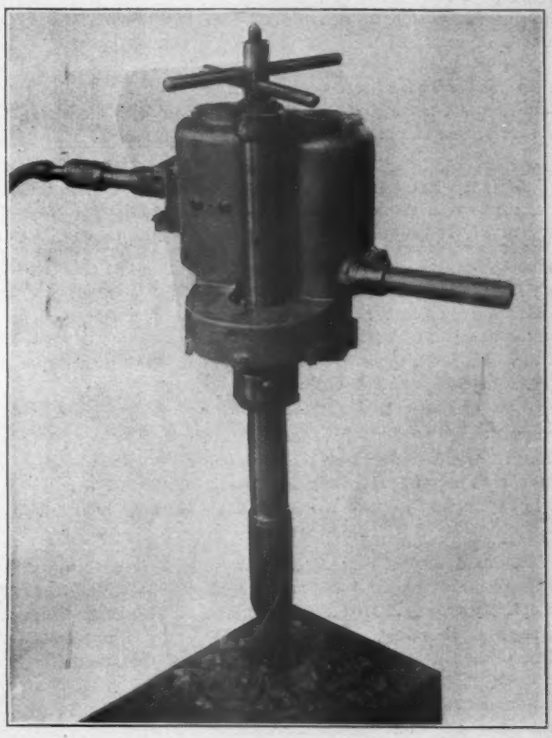


Fig. 2.

effected. In rolling flues the No. 7 machine completed 10 in 2 minutes 37 seconds, in each case the roller being withdrawn by reversing the motion of the machine. After rolling a Boyer hammer, also made by the Chicago Pneumatic Tool Company, which had been in regular service in the shop for over three years (and not having required any repairs during the time), was used for beading the flues, at the rate of six in two minutes. Fig. 3 shows a tube sheet of a locomotive, which was fitted up for the experiment, and exhibits the machine while rolling short ends of flues about 8 inches long with copper ferrules, which were used for the experiment. After the tubes were fixed in this plate the cutter was attached to the machine and they were cut off. The cutter shown in Fig. 1 cuts the flues off within 1¼ inches from the face of the tube plate, which makes it possible to use a tube 2 inches long for welding out the ends instead of a 6-inch length. This means a saving of 4 cents on each tube cut by the machine. The roller and cutter are fed automatically by the motion of the drill, the feed being obtained by means of a taper pin, which expands the cutting and rolling tools, which are withdrawn again by the reverse motion of the machine. A good account of the work done comes from the road mentioned, in the statement that it is found to contribute 10,000 miles to the life of each set of flues rolled by

the machine, and the uniformity of the work has resulted in an entire absence of trouble from leaky tubes. We are told that the men who operated the tools in these tests were unacquainted with them, and still better records may be expected. The machines, while light, are very strong and well made, and it is not to be understood that their usefulness is confined to the processes mentioned, for motors of this kind are adapted to a great many services in building and repairing machinery. A great many people have been looking for a satisfactory light motor, driven by air, and we believe this to be the best yet offered.

The principal offices for the Chicago Pneumatic Tool Company are Monadnock Building, Chicago, and 122 Liberty street, New York.

EQUIPMENT AND MANUFACTURING NOTES.

The Morse Twist Drill & Machine Company of New Bedford has bought out the T. & B. Company of Danbury, Conn., manufacturers of twist drills.

The Louisville & Nashville has fulfilled the provisional promise made some time ago to raise wages from the cut of 1893 to the former rates, the change taking place January 1.

The "Security Lock Bracket" furnished by the Chicago Grain Door Company is to be applied to 1,000 box cars for the Wisconsin Central, to be built by the Michigan Peninsular Car Company.

The Schoen Pressed Steel Company has recently received orders for steel cars of 100,000 pounds capacity from the Pittsburgh & Lake Erie, 500 cars; Lake Shore & Michigan Southern, 500 cars, and Baltimore & Ohio, 1,000 cars.

The syndicate headed by Joseph Leiter of Chicago has not only bought the Rhode Island Locomotive Works, but also the foreign rights in the Hoadley-Knight compressed air patents, and it is reported that the works will be entirely refitted.

Mr. Charles Hansel, Vice-President and General Manager of the National Switch and Signal Company, is to address the New York Railroad Club on the subject of Railroad Signaling at the regular meeting, January 19. A comprehensive and interesting presentation of the subject may be expected.

Contracts have been let for the extension of the plant of the Westinghouse Electric & Manufacturing Co. at East Pittsburg. The extension includes the erection of shops and an office structure to cover four acres of ground. The proposed improvement involves the outlay of over $200,000. The Carnegie Steel Co. will furnish all of the steel.

The Baldwin Locomotive Works have received an order for 10 locomotives from the Midland Railway of England. It is noted elsewhere that the Schenectady Locomotive Works have an order for a like number from the same road. These engines will have 18 by 24 in. cylinders, 62 in. driving wheels and will weigh, in working order, about 92,000 lbs.

An effort to secure uniformity in car sills will be made in connection with a committee report at the next Master Car Builders' convention. The circular issued by the committee requests information with regard to sills used for cars of 50,000 pounds capacity and over. There are good reasons for attempting to secure uniformity in this detail and, we believe, no objections.

The Pall Mall Gazette says that the Midland Railway Company has been compelled to order the construction of twenty freight locomotives in the United States, owing to the large number of advance orders held by the English locomotive works, and a dispatch from Schenectady states that the Schenectady Locomotive Works have an order for ten mogul engines, with 18 by 24 in. cylinders, for that road.

The consolidation of the Union and the National Switch and Signal companies was announced some time ago. At a meeting held in Pittsburgh Dec. 13 an issue of $500,000 in 5 per cent. bonds was authorized, the number of directors was increased from five to seven, Messrs. Oakleigh Thorne and Robert Pitcairn being elected as additional members of the board. In the future there will be two vice-presidents, Mr. Thorne being the first and Mr. E. H. Goodman the second.

Mr. M. J. Martinez, member of the American Society of Mechanical Engineers, has received the appointment of resident agent at Havana, Cuba, for the Snow Steam Pump Works. He will be prepared to furnish pumps of the most modern designs made by the Snow Steam Pump Works, especially adapted for the requirements of the sugar industry in Cuba and Porto Rico. Mr. Martinez will conduct the business in his own name as consulting and contracting engineer.

The Babcock & Wilcox Company report the sale of 600 horse power of boilers to the Northern Pacific Railroad Company for supplying steam for power, heating and electric lighting for new shops at Brainard, Minn. They also report the sale of 500 horse-power Babcock & Wilcox boilers to the Boston & Maine Railroad, to be used in the electric power plant of the Portsmouth & Dover Railroad Company, which will be operated in connection with the Boston & Maine Railroad, using electric power.

Nearly all of the new freight equipment ordered by Receivers Cowen and Murray of the Baltimore & Ohio Railroad during the past few months, will be delivered by Jan. 15. The orders consisted of 3,000 standard box cars, from the Michigan Peninsular Car Company; 1,000 box and 1,000 gondolas from the Pullman Company; 2,000 box cars from the Missouri Car and Foundry Company; 1,000 steel coal cars of 100,000 pounds capacity from the Schoen Company, and five 50-foot modern mail cars from the Pullman Company. These cars are equipped with the Westinghouse air brake and M. C. B. automatic couplers.

The Joseph Dixon Crucible Company sends us a quotation from Mr. Wm. Hooper, of Ticonderoga, N. Y., called forth by the notice that has recently been given to the old sign in possession of the Western Society of Engineers at Chicago. The words "Harper's Ferry," painted in black, stand out as boldly as when they were first formed by the artist's brush, while the wood around the letters, which was painted with white paint, has worn away about one-sixteenth of an inch. Mr. Hooper says in part: "I have seen signs that have been painted with black paint directly on the clapboard of the building. The lettering was good after the paint on the balance of the building has disappeared, and after this the whole building was painted over, lettering and all, and the lettering obliterated; yet within ten years afterwards the old black lettering appeared again quite freshly to view. I suppose the paint for the lettering was made of linseed oil and lampblack. I believe, however, that finely ground graphite mixed with pure linseed oil, will last as long, or longer, than any other paint ever known of or used. I had a large iron casting which laid in my mill yard for over thirty years. It was painted with only one coat. The old casting was broken up and sold for old iron last month, and I noticed that the paint on the pieces of casting, even after being broken up, looked quite fresh. If the surface to be painted is perfectly dry when the finely ground graphite is applied, the paint will prove the most lasting paint known, because if time eliminates all of the oil, the graphite seems to adhere to the surface painted just the same as a piece of paper or wood will appear after it has been rubbed with a lead pencil or a piece of graphite. No other pigment known to me will remain on the surface painted after the oil has been thoroughly destroyed."

Mr. J. W. Duntley, President of the Chicago Pneumatic Tool Company, sailed for Europe since the appearance of our previous number, and will give his attention to the interests of the concern in Great Britain and on the Continent. The trip is made necessary by increasing foreign business, and we have reports showing that the demand for pneumatic tools in this country is larger than ever before. The facilities for manu-

facturing are employed to their full capacity to keep up with the increased demand on account of the present activity of the ship and navy yards, and the railroad orders are also greater than ever before.

American electric railroad equipment has received a substantial recognition for its good design and reliability in the form of an order for eight electric locomotives for the operation of the tunnel of the Paris-Orleans Railway, in Paris. This contract was secured in the face of the strongest European and British competition, the negotiations having covered two years. The transmission system will use three-phase generators and rotary converters, changing the alternating to a 500-volt direct current. The reason for the American success is stated to be superior experience and satisfactory examples of successful practice, the question of cost being virtually eliminated.

The Newport News Ship Building and Dry Dock Company is constructing a timber dry dock with concrete entrance. The clear length will be 806 ft., the breadth at the bottom 80 ft. and breadth at the top 162 ft. The depth over the sill is 30 ft. at mean high water, the range of the tide being 3 ft. The bottom will be of concrete, upon piling, and the interior of timber. The caisson will be of steel, with trimming tanks so arranged that it will not be necessary to pump out the water ballast. There will be two centrifugal pumps, driven by upright compound engines, that will pump out 200,000 gals. per minute and empty the dock in two hours. There is also a drainage pump, with 18-in. suction and discharge. The dock will accommodate the largest ocean liners or two first-class battleships.

The Manufacturers' Advertising Bureau, 126 Liberty street, New York City, turns the second decade of its existence with the close of the year 1898. Mr. Benj. R. Western, the original and present proprietor, established this unique business in 1879, and his success in the particular work he undertakes for his clients is widely recognized and taken advantage of by many of the representative manufacturers of the country. The bureau is a recognized authority on trade journal advertising, and handles the newspaper work and advertising of manufacturers using such publications so as to insure good results from the expenditure for such purposes. Its system furnishes a practical relief to its clients, and has brought the highest praise and commendation of conservative business men. The twenty years past have established the Manufacturers' Advertising Bureau as one of the solid institutions of the country, and copies of its booklet, "Advertising for Profit," may be had for the asking, by inclosing a business card.

The Railway Educational Association has been incorporated under the laws of New York with a capital of $50,000, and its headquarters are at No. 1 Madison avenue, New York. The association was organized to conduct "The Railway Correspondence School" that was established in May, 1897, by Mr. George H. Baker, its purpose being the instruction of railway employees in the best methods for performing their duties. Instruction is given by means of printed lesson books, issued weekly by mail. These also contain examination questions which, when answered, are read by instructors of the school and used as means for further instruction. As directors the school has the indorsement of the following prominent railroad men: Mr. Paul Morton, Second Vice-President of the Atchison; Mr. Edwin Hawley, Assistant General Traffic Manager of the Southern Pacific, and President of the Minneapolis & St. Louis; Mr. George R. Brown, General Superintendent of the Fall Brook, and Mr. George H. Baker. Since its establishment the school has given two courses of instruction, one course for engineers to make them expert and economical in the performance of their work, and fit them for promotion to official positions in the mechanical department, and one course for firemen to likewise benefit them and fit them for promotion to the post of engineer. There are now on the railways in the United States about 74,000 engineers and firemen. Over 1 per cent. of this number, or 840, have joined "The Railway Correspondence School." The price of scholarship in the courses for enginemen was $18 in 1897, but is now $20, payable in four monthly installments of $5 each. The value of the instruction appeals to the men, and is appreciated by the officers, who find direct advantages from the improvement of their subordinates.

BOOKS AND PAMPHLETS.

Differential and Integral Culculus for Technical Schools and Colleges. By P. A. Lambert, M. A., Assistant Professor of Mathematics Lehigh University. New York: The Macmillan Company, 66 Fifth avenue, 1898, price $1.50.

This is a book for students in technical schools and colleges, and according to the author's preface, its object is threefold. By a logical presentation of principles to inspire confidence in the methods of infinitesimal analysis, by numerous problems to aid in acquiring facility in applying these methods, and by applications to problems in physics, engineering and other branches of mathematics, to show the practical value of the calculus. The work is divided according to classes of functions, and the practical applications are introduced at the start with the object of at once engaging the interest of the student. Differentiation and integration are treated simultaneously and economy in time and effort is secured by the use of trigonometric substitution in simplifying integration. The idea of the author to show the connection between the calculus and practical work is an admirable one, which is well carried out as far as areas and volumes and radius of curvature are concerned. and he has attempted to depart from the too generally accepted idea among professors of mathematics that the subject should be taught for its own sake alone. This attempt is commendable, and should be encouraged, but we think it is not carried quite far enough.

Compressed Air Production, or the Theory and Practice of Air Compression. W. L. Saunders. Illustrated, 58 pages. Published by "Compressed Air," Havemeyer Building, New York, 1898, price $1.00.

This is a compact work which admirably fulfils its title. Mr. Saunders is authority on air compression, and this concise treatment of the engineering principles of the subject will be welcomed by the many users of compressed air. A prominent feature of the book is the record of tests made by various authorities. A large number of different forms of air compressors are illustrated and the book contains a great deal of information that will be useful to those who use or contemplate using compressed air. The matter has appeared in the pages of "Compressed Air," but this form is a convenient one that will be appreciated. Moreover, we are informed that many of the numbers containing the original articles are now out of print, which makes the book more valuable. The treatment is complete, and not too technical for readers who are not well qualified to consider mathematical discussions.

"Catalogue of the Hopkins Railway Library." By Frederick J. Teggart, B. A., Librarian, Leland Stanford Junior University, Palo Alto, Cal. 231 pp. Price, $1.50.

This catalogue undoubtedly gives the most complete list of books upon the subject of railways in existence. It is not a new publication, and has been reviewed in these pages before; occasion arises, however, for calling attention to it again. The Hopkins Railway Library, which is now a part of the library of the Stanford University, was built upon a collection of books upon the subject of railways started by Mr. Timothy Hopkins, of San Francisco, while treasurer of the Southern Pacific Company. In 1892 the collection, then numbering 2,000 volumes and pamphlets, was presented to the university, and provision made for its maintenance and increase. The collection has grown remarkably in the past few years, and it is now the most extensive and valuable collection on this important subject in the country. The publication of the catalogue makes the collection useful to those interested in the subject, and serves to direct attention to the value of a railway library, of which very few are available.

The classification of the catalogue includes bibliography, a list of periodicals and transactions, dictionaries relating to transportation subjects, fiction and verse, general books on railways, history and biography. The books on the railways of various countries and those on economics and law are next recorded, and the closing divisions of the subject are arranged as follows: Construction, equipment and operation, followed by a division devoted to local railways. At the end of the book is an index of the personal names which appear in the titles or notes throughout the catalogue.

On examining this book one is impressed with the variety of subjects covered and their importance. We are glad to direct attention to the extensive literature of railways and be-

lieve that interest should be stimulated in its collection and preservation.

Railway Engineering, Mechanical and Electrical. By J. W. C. Haldane, Civil and Mechanical Consulting Engineer. Illustrated with plates and engravings, 562 pages. New York, Spon & Chamberlain, 12 Cortlandt St. 1897. Price, $6.00.

This book is very attractively bound and is well printed, with the important exception of many of the engravings. Its exterior appearance promises so much that the reader is disappointed upon the first glance at the pages. The subject is too large for a single volume, and yet the author finds space enough to present illustrated descriptions of a large number of machine tools, and we even find a large plate of a highway traction engine and another of a horizontal band sawing machine. These bear a certain distant relationship to railroad matters, but their appearance in a work by an engineer on "railway engineering" is hardly justified. The plain truth about the book, as we see it, is that a considerable amount of advertising matter has been included under a title which is somewhat misleading. The faults of the book are so manifest as to obscure the view of its good points. Readers may obtain information in regard to railroad shop practice, but at the cost of spending a lot of time on descriptions of machines for which they will not want to consult such a work.

The Metric System of Weights and Measures. Issued by the Hartford Steam Boiler Inspection and Insurance Co. Hartford, Conn., 1898. 196 pp., 3½ by 5¾ inches; sheepskin. Price, $1.25.

This convenient little book contains an elaborate set of tables for converting metric into English units and vice versa. Its object is thus stated in the preface: "The metric system of weights and measures is used so universally in foreign books and periodicals that much time is consumed and no little annoyance incurred by the American reader in translating these units into their English and American equivalents, by the aid of any of the reduction tables that have yet been published. It therefore occurred to the undersigned that a handy pocket volume for facilitating comparisons of this kind might be acceptable to engineers and scientific workers generally." In addition to tables of linear and surface measures, it includes weights, liquid measures, volumes, power and heat units. The tables include several that are not often used, and if these were omitted in order to lengthen the scope of the others, it would be an ideal collection.

A. D. Lectra's "Short Cut Calculation," Containing the Most Practical Methods of Calculation. Published by A. D. Lectra. West Superior, Wis. 140 pp. Cloth. Price, $1.25.

The author's experience of many years as an expert accountant has given him a large number of short-cut methods of calculations, and checking accounts and process of figuring. Many of the methods will be found valuable even to those who do comparatively little calculating. The author gives many rules for the assistance of those who figure up freight charges and work of similar character. He does very well until he gives the "Average proportions of the various parts of locomotives," and informs the reader that the crank-pin should be one-fourth the diameter of the cylinder, valve stems should be one-tenth the diameter of the cylinder and that "wrought iron tires wear about one-twelfth of an inch per annum."

Annual Report of the Board of Regents Smithsonian Institution, showing Operations, Expenditures and Condition of the Institution to July, 1896. Government Printing Office, Washington, 1898.

The Purdue Exponent. Electrical Number.

The November, 1898, number of this wide awake college publication contains several articles that indicate the character of work done at this school. It begins with "Physics in Electrical Engineering," illustrating the facilities in electrical engineering, followed by a description of the dynamo laboratory. Other subjects are "The Uses of the Storage Battery in Railway Work," "Electrical Transportation," "The Commercial Aspects of Electrical Engineering," "The Training of An Electrical Engineer," "Wireless Telegraphy" and "Long-Distance Transmission of Power." This is the first of a series of special numbers on the departments of Purdue University.

Colonel Roosevelt's account of "The Rough Riders," which begins in the January Scribner's, although prepared in the heat of the campaign for the Governorship, shows no signs of hurry or fatigue. It is filled with humorous characterizations of the strangely assorted company of all types of Americans that went into the making of that unique regiment. The clear-cut idea which Colonel Roosevelt had in mind in getting up the regiment is revealed in this article and accounts in great measure for the successes achieved.

Baldwin Locomotive Works Record of Recent Construction, No. 9. December, 1898.

This pamphlet of 32 pages is uniform with its predecessors, and contains illustrations and the chief dimensions and characteristics of locomotives recently built by this concern. Fifteen designs of locomotives are shown, all but three of which are heavy, and three are of the Vauclain compound type. Our readers are advised to secure these pamphlets as they appear, because they constitute a valuable record of American and foreign practice, as shown in the product of these extensive works.

The Watson-Stillman Company, of New York, has just issued a unique catalogue. It is at the same time a catalogue of the hydraulic tools and miscellaneous machinery manufactured by the firm, giving a small picture of each machine or tool, and an index to the complete catalogues that must be consulted for details and explanations. Mr. Stillman gives a great deal of attention to his catalogues, and his system is one of the best. This index presents the large variety of tools in condensed form and each engraving represents from one to about 20 sizes of tools, a complete illustrated description of each being given on a loose sheet, which may be called for by its number, and the sheet number is printed below the engraving in the index catalogue. These sheets are grouped in various combinations to suit the convenience of correspondents, and are neatly bound for the detail catalogues in the various lines or groups of machines or tools. This is necessary because of the immense variety of the product of the works, and the large number of interests to which the tools are necessary. It is impracticable to put the whole into a single volume. The continual production of new and improved appliances is another reason for using the loose plates. Those using hydraulic machinery of any kind will find this index useful as a guide to further correspondence. The engravings on these sheets are nearly all wood cuts, and are examples of clearness not often found in catalogues of any kind. They are the best that the engraver's art affords.

Pneumatic Tools, The Q. & C. Company. The valveless pneumatic tools formerly manufactured by the Ridgley & Johnson Tool Co., of Springfield, Ill., are illustrated and described in an admirable catalogue issued by the Q. & Co. Company, who now control and manufacture them. These tools are used chiefly for riveting, chipping, caulking, beading flues, cutting stay bolts, chipping iron and steel castings, stone cutting and stone carving. The chief claim for these tools is simplicity. They are valveless, the working piston being its own valve, and they have but few parts. All tools of each size are made on the interchangeable plan, so that a part of one tool will fit all of the same size. The catalogue not only explains the tools themselves by aid of sectional drawings, but it gives the capacities of each size, and shows the character of work that they will do. The company announces its readiness to submit estimates upon complete pneumatic plants, including compressors. The catalogue gives information in regard to the selection of tools for different kinds of work, and will be found interesting and profitable reading by those who are using pneumatic tools for riveting, caulking or chipping. The catalogue contains a number of letters reproduced from the originals, giving the opinions of prominent railroad, ship-building and manufacturing officers upon the value of the tools, and it closes with illustrated descriptions of some of the shop tools manufactured by this company. We desire to compliment the Q. & C. Company for the excellent catalogue, its clear, concise statements, and unusually good engravings being specially worthy of mention.

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